# The Foundry Trade Journal

AND

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## NOTES AND COMMENTS.

### The British Workman.

On the subject of the British workman's attitude to his work, Dr. W. Rathenau, of Berlin, says in a book just published, that "The Englishman, well-to-do, healthy, and muscular, loves work, but he will not sacrifice himself for it. He demands his week-ends, his evening hours, country life, and sport. Anyone starting a new industry in England to-day will find himself in a tight corner. Materials are to be had in plenty, and transport facilities are ample, but the difficulty is to get good technical men. German schooling, learning, and practice are not to be had, and what is obtainable costs quite as much as the best German quality. The Englishman is capable enough, but will do only what is established practice; anything complicated or extraordinary he declares impossible, and so long as the business goes well he is pleased with himself; but when it goes badly he lays the blame upon his employers or somebody else. In England the general business expenses are exorbitant, and a factory which might be taken for a model is scarcely to be met with. The enormous coal business is conducted with the most primitive plant, and the technology of metal is not to be compared with that of Germany and America."

This writer's comments can scarcely be based on any of our prominent works, such as the large iron and steel concerns, but there can be no doubt that amongst our smaller workshops and industrial establishments there is a striking lack of men with a good technical training. The bug-bear of "established practice" has hampered many a progressive employer and workman, though with the rise of the technical schools the horizon of both is becoming enlarged. It is encouraging to note how well attended are the technical classes of such institutions as the Sheffield University; and not only is the attendance well maintained, but an increasing number of students are taking up the highest or "honours" course. We repeat, this is an encouraging sign, for

without descending to invidious comparisons between the technology of the Englishman and his foreign rivals, we may say that there is very apparent room for advancement in this direction. Favourable industrial conditions may be somewhat responsible for it, but it cannot be denied that, regardless of our ability to meet international competition, we have not made the strides in national technical education that our advance on other scientific lines would seem to warrant. The percentage of our workers with even a slight knowledge of the technical side of their work is so small that the labours of the few ardent workers in the cause of education are more than welcome. As the educational forces that are developing in our midst become more prominent we shall find the boy starting at his trade, not with the sole idea of earning the average man's wage at the earliest possible moment, but determined to go farther than his predecessors and make his work the subject of scientific study. The hope of any trade must be in the youngsters, and as we train them to see possibilities in their work, so shall we secure the advancement that is so necessary if we are to keep our place in the field.

### What Sheffield is Doing.

At the Sheffield University the technical side of education is given considerable prominence, and how far the value of the applied science department is appreciated by the young men of the city is to be seen in the number of students who take advantage of the opportunities offered. The evening classes appeal to a far larger number of students than the day classes, and provide for young people in many of the leading branches of trade, including engineering, the steel trade, electrical trades, and the electro-plating and plating trades. Last session there were 1,386 students attending the evening classes. The technical side of the University is divided into two departments, one for day students and one for evening students, the day students being those who have the opportunity to devote a number of years to their studies in the day time before going into works, while the evening courses are intended for those who are already engaged in the works. There are several scholarships and free studentships. The Sheffield Technical School, as was to be expected, has made an important feature of the study of steel, and has specialised to such an extent as to be the national centre for the teaching of subjects connected with the iron and steel industries. The metallurgical department is fitted with a fine equipment for its purpose, and the young students of Sheffield are taking full advantage of the opportunities which it affords. Every year additions are made to the courses, the latest being classes for automobile engineering, boiler-maker's work, telegraphy classes, and classes for the study of gas manufacture.

### Foundry Classes.

Simultaneous with a request from a correspondent for information concerning practical foundry classes, comes the prospectus of classes held at the Darlington Technical College, under the Darlington Education Committee. The curriculum is an extensive one, and amongst other subjects are included applied mechanics, book-keeping, building trades, electrical engineering, languages, chemistry, iron and steel manufacture, machine construction, magnetism and electricity.

Of particular interest is the foundry class, which, we regret to say, does not appear to have received the support that might be expected in the district. The object of the course is to supplement the practice in the foundry and to give the intelligent workman or foreman a knowledge of the principles which govern it. Sufficient examples of actual practice are dealt with to enable others not practically engaged in the foundry, but to whom some knowledge of ironfounding is necessary, to follow the course. The syllabus includes instruction on the general properties of metals, the chemical composition and physical properties of pig-iron, the effects of carbon, silicon, sulphur, phosphorus, aluminium, and other elements on pig-iron, the special adaptability of certain classes of iron for special work, the production of pig-iron, conditions affecting the composition of the iron produced, changes that take place during melting and remelting, the principles of metal-mixing for various purposes, the influence of shape on strength and the mode of casting, curving and shrinkage, scrap, and burnt iron.

Sands and their properties, sand mixing for various classes and weights of castings, etc., flasks and boxes of various kinds, and moulding tools are also included, in addition to instruction regarding cores and core-making, loam moulding, machine moulding, the production of chilled castings and malleable castings. Cupolas of various types and their

management, fuel and fluxes, blast arrangements and blowers, and air furnaces are further subjects.

A small equipment is being prepared whereby students may perform some practical work, and in connection with iron and steel manufacture a course of experimental work in fuel and iron analysis which would be very useful to students in the ironfounding class, is also arranged.

### Aluminium Founding.

With the rise of the aluminium branch of the foundry trade several curious features have been noticeable. That the foundryman does not find aluminium work all plain sailing may be gathered from a glance at some of our recent "Queries" columns, for quite a goodly percentage of the difficulties there expressed by correspondents have been in connection with aluminium. In the early days of the metal's history there was in the minds of most people a certain amount of romance associated with its manufacture, and this was for some time influential in keeping aluminium work in the hands of only a few; for a good deal of secrecy surrounded the methods employed for producing and working the metal. When, however, the metal became better known and took its place in the industrial ranks the other extreme was rushed to, and nearly every man who knew anything of foundry work decided he could cast aluminium successfully. The idea that any good brass and bronze founder could also produce good castings with the lighter metal, soon began to lead many men into difficulties, and at last it became recognised that something in the way of specialised knowledge was necessary for successful aluminium work. There is probably no more deceptive metal in the hands of the founder; it melts readily in the crucible, and it is not a very difficult matter for a good brassfounder to turn out a casting of aluminium with a smooth surface and a clean white colour. But under that same clean-looking surface may lie enough trouble of the nature of blowholes and such like defects to satisfy any foundryman. The fact of the matter is, the conditions ruling in aluminium work are so different from those governing other metals that a special study is necessary to ensure success; though, of course, it is quite possible for a man with not much experience of the metal to often get good castings. But since the melting point is so much lower than brass and bronze, and the oxidation of the molten metal so much greater, aluminium stands distinct from other metals in its requirements. There is no special secret in casting the metal, as was once largely believed; the road to success lies in a clear understanding and knowledge of the work, which is best obtained by practical experience and observation. The shrinkage in cooling is an important point to watch if cracking is to be avoided, and to this end special care must be given to obtaining suitable cores. When the metal is thoroughly understood it presents no more difficulty to the foundryman than any other, but, on the whole, the best success is obtained in foundries which specialise in it, for thus its various peculiarities are better understood and more easily dealt with.

### The Nature of Alloys.

In the course of a lecture on alloys, delivered recently, Professor Turner said the object of alloying metals was not to reduce the cost of production, though this was frequently an incidental advantage, but by alloying the common metals, which were only about thirty in number, a class of practically new metals was obtained, the variety of which were almost infinitely numerous. Alloys differed in colour and appearance from their constituent metals, but the most important changes were increased tenacity and durability, as a result of which alloyed metals such as gold, silver, or copper, wore much better than the pure material. It was formerly the custom to regard alloys from a chemical point of view, and to class them as compounds; but the recent applications of the microscope and the pyrometer in metallurgical research had shown the intimate connection between alloys and other solutions, such as those of salts in water, or silicates in slags or glasses. In some cases the constitution of a solution was relatively simple, such as with common salt and water, or alloys of tin and lead. In other series the relationship was much more complex, and that very complexity was often the underlying reason for the commercial importance of the series, as it enabled the metal worker to obtain entirely different properties from the same materials by suitably varying the mechanical or thermal treatment.

### British Foundrymen's Association.

The Manchester Branch held their opening meeting on Saturday, the 3rd inst., at the Victoria Hotel, Manchester, when a paper on "Alloys" was read by Mr. Percy Longmuir, Carnegie Medallist, of Sheffield.

# British Foundrymen's Association.

## The Annual Convention.

(*Continued from page 540, September.*)

### WEDNESDAY'S PROCEEDINGS.

The PRESIDENT: Gentlemen, I have to announce letters of apology for non-attendance from Mr. W. H. Sherburn, of Warrington, Mr. C. Morehead, of Rugby, and Professor Turner, of Birmingham.

The first paper this morning is that by Mr. Munnoch. Mr. Munnoch is known

MR. P. MUNNOCH.

to almost all of you as a practical metallurgist of Middlesbrough, a man who has made a careful study of pig-iron, and whose previous papers have proved very valuable and helpful to our members. I have not the slightest doubt that such will be the case with the one he is to read to us this morning.

MR. MUNNOCH: Before I commence, I ought to say that when I gave the title of the paper I was not quite certain of the lines I should follow. I found on considering the subject that it was rather big, so that I shall just give one or two examples, chiefly in reference to manganese and phosphorus.

### THE PRACTICAL APPLICATION OF CHEMISTRY TO THE FOUNDRY.

This is a subject which can be considered from many different points of view, but it is intended to deal chiefly with the use of analysis in the selection of iron, and the relation between characteristic properties and composition.

Taking first the consideration which led to the introduction of chemistry into the foundry, we have on the commercial side the desire to take advantage of any saving which may be possible, either by substituting cheaper brands in place of any high-priced brands of iron in use, or by taking advantage of any difference or change in the price of irons from the various districts with which the consumer may be in touch.

On the operative side there is the desire to have more control over the composition of the metal used, thereby making the product:—

1st. More suitable for the purpose for which the castings are required in respect to strength, hardness, or chill.

2nd. More suitable to the requirements of the machine shop as regards regular degree of hardness for rapid machining.

3rd. More suitable to the requirements of the foundry as regards shrinkage, fluidity, life and freedom from dirt as oxide or graphite.

4th. Eliminating wasters due to variations in the composition of the iron used and avoiding wasters attributed to "bad

metal," but which may be due to other causes, such as unsuitable design, defective work or lack of judgment in the methods of moulding, coring, venting, pouring, feeding, etc.

### The Utility of Analysis for Foundry Work.

Although much has been done in the application of chemistry to foundry work there are still some who question its utility or value.

It is a well-established fact that the physical properties of cast-iron depend more or less upon its chemical composition. Therefore, the success or otherwise attending the use of analysis in the foundry must depend upon the conditions under which it is given a trial, and upon the capability of the chemist who makes the trial. Want of success in some particular instance should not lead to general condemnation, but rather to searching enquiry into the cause of failure. The fault will be found to lie not with the reliability of analysis as a guide, but with the conditions or manner in which it is applied.

The art of metal mixing in the foundry rests upon the fact that the properties of every brand of pig-iron made depend upon the materials used and the method of manufacture followed. Hence we have mixings in which figure certain brands which have a reputation for possessing certain properties and of giving certain approximate results. The analyses of the different brands or classes of pig-iron show that the composition of these irons also depends upon the materials used and the methods of manufacture followed. It is also found that, generally speaking, irons similar in compositon have similar physical properties. It is therefore assumed that physical properties depend largely upon composition or analysis.

It must not be assumed that, in our present state of knowledge, analysis removes or even explains all the difficulties of the foundry, as in addition to composition the mechanical or physical properties depend upon the effects of melting, casting, and cooling, the exact influence of which it is not always possible to determine or define.

When comparing castings which have been successfully used for various purposes, it is plainly apparent that absolute uniformity of composition is not to any great extent necessary except in a few special cases. It is not so much a question of having a definite percentage of one or even each constituent present, but is more a question of having a certain relative proportion between the constituents present.

### Character and Selection of Pig-iron.

When comparing the analyses of pig-irons made in the different iron-producing districts, it is seen that the chief

TABLE II.—*Example A.*

| | Graphitic carbon. | Combined carbon. | Silicon. | Manganese. | Phosphorus. | Sulphur. |
|---|---|---|---|---|---|---|
| Runner ... ... | 3.05 | 0.38 | 1.38 | 0.85 | 0.96 | 0.068 |
| Spongy — Top, centre ... ... | 2.57 | 0.41 | 1.58 | 0.91 | 0.83 | 0.270 |
| Very spongy — Below top .. | 2.75 | 0.19 | 1.49 | 0.66 | 0.89 | 0.123 |
| Solid — Outside corner ... ... | 2.90 | 0.75 | 1.40 | 0.56 | 1.02 | 0.079 |
| Solid—Bottom ... | 3.15 | 0.31 | 1.46 | 0.47 | 1.01 | 0.068 |
| | *Example B.* | | | | | |
| Top... ... ... | | 0.55 | | 0.75 | | 0.167 |
| Middle ... ... | 2.97 | 0.58 | 1.49 | 0.63 | 0.024 | 0.089 |
| Bottom ... ... | | 0.51 | | 0.63 | | 0.086 |
| | *Example D.* | | | | | |
| Casting ... ... | 2.80 | 0.50 | 1.75 | 0.49 | 0.83 | 0.118 |
| White shot ... | Nil | 2.20 | 0.70 | 0.63 | 5.68 | |
| Mottled shot ... | 1.16 | 1.25 | 0.93 | 0.48 | 4.88 | 0.031 |
| Casting ... ... | 2.55 | 0.60 | 1.65 | 0.49 | 0.84 | 0.119 |
| Mottled shot ... | 2.02 | 0.75 | 0.98 | 0.50 | 3.20 | 0.037 |
| Grey shot ... | 2.44 | 0.76 | 1.26 | 0.45 | 1.92 | 0.046 |
| Casting ... ... | 2.74 | 0.62 | 1.63 | 0.51 | 0.88 | 0.091 |
| Grey shot ... | 2.45 | 0.85 | 1.32 | 0.43 | 1.70 | 0.031 |
| | *Example C.* | | | | | |
| Top of Casting... | | .06 | 2.35 | 1.16 | 0.96 | 0.436 |
| Middle of ,, ... | 3.20 | .09 | 2.28 | 0.50 | 0.94 | 0.078 |

TABLE I.

| | Manganese. Usual limits. From. | To. | Average. | Phosphorus. Usual limits. From. | To. | Average. |
|---|---|---|---|---|---|---|
| Hematite from Cumberland ores ... ... | 0.08 | 0.30 | 0.20 | 0.025 | 0.024 | 0-035 |
| Hematite from imported ores | 0.50 | 1.80 | 1.00 | 0.020 | 0.065 | 0.055 |
| Cleveland from Cleveland iron-stone ... ... | 0.40 | 0.65 | 0.50 | 1.50 | 1.65 | 1.55 |
| Cleveland from mixed ores etc. | 0.40 | 0.75 | | 0·90 | 1.75 | |
| South and West Yorkshire ... | 0.50 | 1.50 | 1.00 | 0.80 | 1.20 | 1.00 |
| Lincolnshire ... | 1.20 | 2.20 | 1.50 | 1.10 | 1.30 | 1.20 |
| Derbyshire ... | 0.40 | 1.20 | | 1.00 | 1.50 | |
| N. Staffordshire | 1.20 | 2.80 | | 1.20 | 1.70 | |
| S. Staffordshire | 0.50 | 1.50 | | 0.50 | 2.00 | |
| S. Staffordshire (cold blast) ... | 0.40 | 0.80 | 0.50 | 0.30 | 0.60 | 0.50 |
| Shropshire ... | 0.50 | 1.20 | | 0.50 | 1.00 | |
| Shropshire (cold blast) ... ... | 0.50 | 1.00 | 0.60 | 0.40 | 0.60 | 0.50 |
| Northampton-shire ... ... | 0.20 | 0.50 | | 1.10 | 1.80 | |
| Lancashire ... | 0.60 | 0.90 | 0.70 | 0.60 | 0.80 | 0.70 |
| Nottinghamshire and Leicester-shire ... ... | 0.40 | 0.60 | 0.50 | 1.00 | 1.20 | 1.10 |
| N. Wales... ... | 0.40 | | | | 1.75 | |
| S. Wales (cold blast) ... ... | 0.50 | | | | 0.35 | |
| Ayrshire ... ... | 1.00 | 2.80 | | 0.50 | 1.30 | |
| Lanarkshire ... | 0.60 | 1.50 | | 0.60 | 1.30 | |
| Stirlingshire ... | 0.80 | 1.40 | 1.00 | 0.60 | 0.90 | 0.80 |

difference is in the amounts of manganese and phosphorus present. It is also seen that the irons produced in each particular district have very similar contents of these elements.

Table I. gives the usual limits of manganese and phosphorus, and also the average amounts where these are sufficiently uniform.

In considering the selection of pig-iron for different purposes the necessary amounts of manganese and phosphorus must be obtained by buying from districts where suitable irons are made. In some cases the irons bought may contain the necessary amounts of these elements. In other cases irons containing high and low percentages are mixed to obtain intermediate amounts. The required silicon and sulphur is obtained by buying to analysis or by the usual method of buying suitable grades or numbers.

At the present time large quantities of iron are carried long distances at great expense, when often iron of similar or even more suitable composition is made within easy reach, and can be obtained at a lower cost. This is due to certain brands having obtained a reputation for certain classes of work. Where this reputation is due to special composition unobtainable elsewhere the demand will continue. The advent of analysis in the foundry is often the means of getting rid of high-priced irons which have no advantage in this respect; and also in some cases of duplicating the composition of those which have. In districts where ores of a limey character are used silicon is usually low; where ores are of a more siliceous character high silicon irons usually predominate. To some extent, however, both high and low silicon irons are made in all districts.

The distinctive feature of the cold-blast irons is low total carbon usually accompanied by low silicon. Provided the same composition could be obtained in metal from a hot-blast furnace there is every reason to suppose that physical and mechanical properties would be similar. Experience with hot-blast irons which to some extent approach cold-blast iron in composition, confirms this view. With hot-blast when using the same or similar ores, iron having a higher total carbon is usually produced.

Steel scrap added to the charge is used to some extent for reducing carbon and increasing strength. The results obtained vary considerably, owing to the uncertainty of the resulting total carbon content. The resulting metal is also in a more or less oxidised condition, which may cause trouble in the foundry. This may be remedied to some extent or avoided by the addition of spiegel to the cupola charge or the addition of some deoxidiser as ferro-manganese or special ferro-alloys in the ladle. Several brands of refined iron are made by somewhat similar processes, and in some cases the resulting product is equal or superior in regularity of composition and strength to the cold-blast irons produced at the blast furnace.

In districts where irons are low in manganese, irons high in manganese are imported from other districts. These are used in the mixing to obtain those qualities for which high manganese irons, such as "Scotch" and "North Staffordshire," are noted. These qualities are "life," "fluidity," "cleanness," and freedom from trouble caused by excess of sulphur and presence of oxides. Several brands of these irons are consistently very low in sulphur. Where very low sulphur is necessary, irons low in sulphur must be used, as there is no other method of obtaining very low sulphur in the foundry. Where it is merely the advantages of high manganese that are required, high manganese irons may be bought, or it may be more convenient, and possibly in some cases cheaper, to obtain high manganese by use of spiegel added to the charge, or ferro-manganese in the ladle.

Sulphur usually increases during melting in the cupola. However, when manganese is high, and especially where spiegel or ferro-manganese is used, there is often a decided reduction instead of increase. There is always more tendency for sulphur to increase when melting small scrap than when melting large pieces. The use of borings in the cupola increases sulphur considerably. Silicon varies in the different districts and in the various brands to a considerable extent, also in the same brand from time to time, and therefore must be controlled by buying to specification or by stocking extremes of high and low silicon iron. The use of ferro-silicon is much in vogue in America for increasing silicon, as silicon is generally lower throughout the various grades than is the case in this country. Where increase of silicon is necessary it may be obtained by the addition of ordinary irons high in silicon, or glazed irons may be stocked for this purpose. When low silicon is required, low silicon iron may be used or steel

scrap may be used for this purpose, in which case reduction in total carbon to some extent will also take place. Occasionally, iron in all qualities, from "No. 1" to "white" with below 1 per cent. of silicon, may be obtained and used for this purpose.

At the blast furnaces one often comes across small quantities of iron which would be invaluable to foundries for mixing purposes, but which must be sent out in the ordinary course, as it would not pay to go to the extra expense of picking out and stocking unless there was a known demand at reasonably enhanced rates for such irons.

### Effect of Manganese.

It is not intended to call attention to all the various effects attributed to manganese, as a great deal has already been written on the subject. There are one or two points which have not received much attention, and consideration will be given chiefly to these.

In the foundry the most noticeable feature in connection with manganese is its effect on the appearance of the iron when melted. Iron low in manganese when melted appears to be covered with a film of oxide which gives it a dull appearance. Iron high in manganese always shows a bright, clear metallic surface, free from oxide. When only a medium amount of manganese is present the iron is covered with a rapidly moving film of oxide, which forms rapidly changing geometrical and flowery patterns on the surface of the metal. This is known as the "break on the metal, or it is said to be breaking into "squares." This is usually noticed in the ladles and also on the runners and risers, after pouring, before the metal sets.

Metal high in manganese is said to have "life," as it appears to remain fluid much longer than metal low in manganese. Manganese also increases "fluidity," making iron run much better into fine intricate work. With experience it is possible to estimate the amount of manganese present with a fair degree of accuracy by the appearance of the metal in the ladle.

With below 0.4 per cent. the metal is entirely covered with a film of oxide. With about 0.5 per cent. long rifts with small side shoots suddenly appear and disappear in the film. Above about 0.5 per cent. the breaks in the film increase in number, the activity of the movement increases and the particles of oxide decrease in size with increase of manganese, until finally with about 1 per cent. of manganese the surface appears quite bright and free from film. With high manganese there is less danger from cold shot, as the surface is free from oxide, and two streams of metal will join and intermingle perfectly. Metal low in manganese is practically self-skimming, as the oxide film holds back any dirt on the surface. With high manganese skimming is a difficult task to perform properly, as any dirt on the surface floats about as though on melted grease.

In addition to its effect upon the appearance of metal when hot, manganese also has an effect upon the appearance of the metal when cold. This is noticeable chiefly in small castings. It changes the colour of the skin from a bluish grey with low manganese to a bright surface, showing a brownish tint when manganese is high. This is valuable when ornamental and clean skin castings are required, as the manganese to a great extent prevents the adherence of sand. With small thin castings it is possible to approximate the amount of manganese present by the appearance of the skin.

For small ornamental work, textile work, and all small castings where a good skin is necessary, manganese in fair proportion is a great advantage. It also gives a metal with close grain capable of taking a high polish.

With high phosphorus manganese tends to produce hard and rigid small castings with low deflection, therefore rather brittle, but good for standing wear.

With high sulphur the effect of manganese varies under different conditions; but, generally, it makes small castings harder, whilst there is a tendency to make large castings softer, due to the separation of sulphur as manganese sulphide.

### Effect of Phosphorus.

The chief feature noticed in the foundry is the increase of fluidity with an increase of phosphorus. Phosphorus increases the life of the metal, keeping it fluid longer by lowering the setting temperature, and also decreases the trouble caused by shrinking or drawing whilst setting.

The great disadvantage of phosphorus is the want of resistance to shock which it gives to castings. This is very noticeable in the high phosphorus irons, although test bars tested for transverse and tensile strength may not give greatly inferior results to low phosphorus irons. Phosphorus reduces deflection; for

structural purposes the rigidity imparted is an advantage.

### Effect of Silicon.

Metal low in silicon, when running into a ladle or when being poured into a mould, throws off sparks called "stars," "soldiers," "jumpers," etc.; metal high in silicon does not show this peculiarity. It is possible to estimate the silicon by this as irons containing above about one-half per cent. of phosphorus usually start to throw off sparks when silicon drops below 2 per cent., and the lower the silicon the greater the profusion of sparks thrown off. Hematites give off these sparks when above 2 per cent. of silicon is present. This phenomena is usually attributed to low grade iron, but if silicon is low, it is present whether the iron be No. 1 iron or hard forge iron. Profusion of sparks, however, is an indication of hard castings, due to low silicon.

Silicon is generally stated to increase fluidity. The most fluid irons, however, appear to be those just below 2 per cent. in silicon. High silicon irons are usually sluggish irons. Low silicon irons are most sensitive to chilling action.

### Effect of Carbon.

High percentage of carbon is generally credited with increasing fluidity. This does not appear to be so, as in irons containing excessive carbon there is a separation of carbon as the molten metal cools down, even when the temperature is much above its setting point. This makes the iron thick running and dirty. Iron low in carbon is also not very fluid. The most fluid irons appear to be those of medium carbon without either excess or deficiency of carbon.

### Effect of Sulphur.

When sulphur is high it can usually be detected by the smell of burning sulphur given off from a ladle of molten metal. It becomes apparent when metal contains about 0.08 per cent. This depends, however, to some extent upon the amount of manganese present and upon the temperature of the metal. The smell is caused by the sulphur rising to the surface of the metal as manganese sulphide. This is reacted upon by the oxygen of the air forming manganese oxide, which remains in the ladle, and sulphur dioxide which is given off and is noticed by its strong odour.

The chief effect of sulphur is its power to harden by increasing the combined carbon. Excess of sulphur gives the property of chilling, low silicon increases this effect. Addition of sulphur increases the strength of soft irons low in sulphur, partly by increasing combined carbon and partly by closing the grain.

When taking samples for analysis from castings great care and judgment is necessary owing to the vast difference in composition in different parts of the same casting. This is very apparent in large castings, as the following example from a large intricate casting will show, (*Example A*).

It is not only large castings which vary in this manner, as the analysis (*Example B*) from a 2 in. by 1 in. test bar cast on edge will show. For analysis three ½ in. holes were drilled one above the other on the 2-in. side of bar. The effect of manganese sulphide separating and rising to the top of the casting is plainly apparent in both cases.

Generally, the higher the sulphur present in a casting the harder it is, due to higher combined carbon induced by the sulphur. One would therefore expect that part of a casting containing the highest sulphur to be the hardest part, and also high in combined carbon. This is not the case, as this is usually the softest part of the casting, and is usually low in combined carbon (*Example C*). This is accounted for by the fact that sulphur which has had time to separate as manganese sulphide has no effect on carbon. This is most noticeable in large castings. In small thin castings both the manganese and sulphur tend to increase combined carbon, as the chilling action of rapid cooling takes place before manganese sulphide has had time to form and separate out.

Combined carbon and graphitic carbon sometimes vary considerably in the same casting. Total carbon also varies considerably, soft spongy parts of a casting being usually low compared with the first solidified parts of same casting. Phosphorus also varies to some extent, soft spongy parts being often lower in phosphorus than solid portions, showing that the last liquid portion of the metal which is high in phosphorus has been drained away leaving a porous crystalline mass, usually in the upper centre part of the casting.

Another effect of phosphorus is the hard spots or hard shots often found when machining castings. These have a white steel-like appearance, and when of large

size, sometimes cannot be cut by the machine tool and have to be chipped out before machining can proceed. Mr. J. E. Stead, F.R.S., has pointed out that these are due to small, or sometimes large, blow holes or gas holes formed during setting. After the cell walls are solidified pressure of the shrinking shell forces some of the last liquid portion of the metal into the previously formed holes. The amount of phosphorus present shows at what stage of the setting this pressure has been exerted. The examples shown (*Example D*), are selected from a number of these which have been examined by the author; analysis of the casting from which the shots and buttons were taken is also given.

Solid contraction increases with hardness and shrinkage of the liquid metal increases at same time, therefore we should expect to find most trouble from drawn holes or shrink holes in hard metal. It is soft metal, however, which usually causes greatest trouble in this respect. It is usually found in irons which are deficient in fluidity, due either to low temperature or to composition. Irons with excess of carbon or with very low carbon both tend to produce this effect.

Sponginess is due to similar causes and can usually be remedied by increasing the hardness by use of a lower grade of iron.

Dirty metal is often due to the oxidised condition of cold-melted metal or to holding metal of soft composition too long in the ladle. As the temperature is too low for rapid reaction on silicon and manganese, oxide of iron is formed on the surface by contact with air, and at the same time graphite is commencing to separate. The result is a dirty deposit on the surface of the metal. This collects together and during casting the carbon and oxide react, forming carbide monoxide gas. This gives rise to pin holes, dirt holes, etc.

Holes classified as blow-holes generally include holes formed by air, gas, or steam from mould or cores, air drawn down runners and forced through the metal in the mould, also gases due to oxides of iron and manganese reacting on the carbon in the solidifying metal, or on graphite already separated, or on the carbon or graphite of the moulds. Sulphur is also an indirect cause of these troubles due to the formation of manganese oxide from sulphide of manganese.

Shot holes and pin holes also are largely due to oxidising conditions of melting and handling the metal. Dirt holes are those which contain oxides from the surface of metal, scum from ladle or slag, and are usually the result of bad skimming. Sand holes, caused by sand in the mould, bits of cores or mould are usually recognised as such.

The use, and in some cases necessity, for the addition of alloys to the melted metal is due to the presence of oxides. This trouble is inherent in cast-iron, and whilst it can be reduced considerably by adding oxide-removing alloys or by more suitable composition, it is chiefly by the removal of oxidising conditions of melting and casting operations that the evil can be reduced. As long as cast-iron is used in the foundry it will recur to a greater or lesser extent.

Sufficient attention is not given to the fact that molten cast-iron is more readily oxidised, or burnt, at low than at high temperatures. At high temperatures the iron itself is protected from oxidation by the preferential action of manganese and silicon. Any oxide of iron formed is rapidly reduced by these elements to metallic iron, oxides of manganese and silicon produced by the reaction, together with more or less oxide of iron forming a fluid slag which rapidly rises to the surface of the metal. This action is not so prominent at low temperatures, and is also to a great extent prevented by want of fluidity of the metal. Want of fluidity also prevents any intermingled oxides from rising to the surface very rapidly, and thus being removed as slag.

The bulk of the troubles associated with the casting of iron is connected with this oxidation. The presence of oxide of iron in metal reduces fluidity, and increases and sometimes causes trouble due to shrinkage or drawing. It is also responsible for causing many of the small holes as pin holes, shot holes, due to the reaction between oxide of iron and carbon in the iron producing carbon monoxide gas. Large holes can often be tracted to pieces of solid or semi-solid slag or oxide.

High manganese irons are usually least subject to the detrimental effects of oxidation, but even these irons melted and exposed to oxidising conditions at a low temperature, show these defects to some extent.

Much difficulty is experienced in carrying out investigations in connection with oxidation of cast-iron, owing to the difficulty attending the analysis of iron for oxides and the time required. Therefore, very little has been done in this direction.

The PRESIDENT: Well, gentlemen, as I predicted, we have had a paper full of interest. It is too big an order to discuss all the points mentioned, but it will form a valuable addition to the literature of our members, and one that will be found useful in many cases of trouble as it has a direct bearing on our everyday work. One point I noticed, and on that I am perfectly in accord with Mr. Munnoch. First of all as to total carbon. I am not sure that sufficient attention is paid to total carbon, for this has even a more practical bearing than the question of combined carbon. There is no doubt that by attention to this point you can increase the strength of a low grade iron. That is, if you start with a fairly medium degree of carbon, and increase your total carbon to about 3 per cent. you will increase your strength in proportion. Another question was that of steel scrap added to iron. I have had some experience with this, and find it is rather a dangerous thing. I believe that for castings such as liners or piston rings it will be found a great advantage. I should like the lecturer to classify in some way the amounts of manganese he would use for certain castings and general work. It is a very debatable point, this manganese question. My own experience is that it does not increase wearing properties. With irons of the same degree of hardness, the iron in which the hardness is due to sulphur is a much better wearing iron than one in which the hardness is due to manganese. I have examined several cylinders and other castings, which have worn badly, and have generally found the manganese to be high and the sulphur low. With reference to the phosphorus decreasing the shrinkage in very complicated castings. I find that it is an advantage. When I have to deal with a cylinder of a very complicated design, I find that by increasing the phosphorus up to 1 per cent. the benefit of decreasing shrinkage more than repays the loss of strength which it may bring about.

MR. BUCHANAN: I am glad Mr. Munnoch has dealt with this question. He supports the attitude I have adopted for some years, and I must admit that there is not always absolute agreement between analysis and physical characteristics. But where they fail, so far as I have seen, is only in the low silicon iron, and it is quite certain that this difference of physical characteristics in irons of apparently similar chemical analysis arises from causes which we have not yet elicited, but which no doubt will by further investigation be found to fall into line with the other metals in which physical characteristics follow the chemical analysis. We cannot, of course, say that we know all that there is to be known, and that chemical analysis tells everything. But, as the lecturer has pointed out to us, the man who mixes pig-iron is most successful when he works from analysis, and we who have adopted it largely in our own works find we can get 99 per cent. of definite result following from definite mixtures. I think there is no law or rule of work in any department which can bring you nearer to exactitude than that. The writer of the paper mentioned the principal difference between cold-blast iron and hot-blast iron, the total carbon and silicon being lower in cold-blast iron than in the hot-blast iron. If it were not for characteristics of that sort it would be as good an iron and would sell at as good a price, but I have been informed by one who has investigated it, that with cold-blast iron another element comes into play, and that is the size of the graphite. I think that has an important part to play in the strength of cast-iron. If you have your graphite large it means you have so many flakes of graphite dividing up the iron, and you will have fracture running along these plates. If you have your carbon in a finely divided state, you will increase your strength. The difference between the graphite to be found in the cold-blast irons gives you principally the reason why one is stronger than the others. With reference to the characteristic appearance of manganese iron in the ladles, in Scotland, I was used to seeing that, but at Middlesbrough, with irons which were low in manganese. I found they gave a clear top with no break in it. The Scotch moulders used to judge of the hardness of the iron by the size of this break which takes place. It is like an enormous number of ellipses, and they are constantly forming and breaking in the most beautiful manner. When they are small, the silicon is high, and when they are large the silicon is low. That is, with a constant manganese you get a small break if the silicon is high, and with the same manganese you get a very large break with the silicon low. We will say that with 2½ per cent. of silicon present the ellipse will measure 2½ in. from point to point. If you get down to 1½ per cent., this ellipse may measure 1½ in., and the Scotch moulder judges the hardness by the size of this ellipse. I think the size of the ellipse

may be conditioned not only by the manganese present, but also by the silicon. With regard to the sparking of silicon iron, I think it is well if one sees a phenomenon just to try to construct a theory. The sparking in star-like forms is undoubtedly due to absence of silicon. If what would otherwise form a star falls dead it means the silicon is excessive. If the silicon is low, then you have the forms the lecturer has referred to. He has referred to the sulphur increasing the combined carbon; here is one of the puzzling things to me. I submit it as a thing on which you can exercise your minds, and possibly at future Conventions give us the result of your investigations. The lecturer says that increasing the sulphur gives increased strength by the increase of the combined carbon. If you take a white pig-iron, the carbon is wholly in combined form; you find it brittle, and get a low breaking strength. You get a maximum strength with a combined carbon about 0.67 per cent. Now, if you get a white pig-iron coming out brittle, because all the carbon is in combination, how is it that you must have a certain amount of this brittle constituent present if you want to get a high strength in the test bar. That is one of those puzzling things which may conceal a very great truth. The filling of blow holes by phosphorus is a very important point, and, I think, supports what Mr. Stead told us yesterday about the pushing out of the phosphide by the forming of graphite and the crystallisation of pure iron. It is an interesting fact that Mr. Munnoch has found in these blow holes such a large percentage of phosphorus. One sometimes wishes that instead of sinking away, the phosphorus would travel along and fill them. Very often we would not mind how they were filled, if they were filled up by something. (Laughter.) I sometimes wonder whether it would be possible to ascertain the exact conditions under which a blow hole is filled by these constituents. Undoubtedly, the iron oxidises on the top, but whether oxide exists in the middle is a very debatable point. We know Dr. Moldenke has written a great deal about oxide. He is right about malleable cast iron, but the two things are different. I have discussed the question with Mr. Stead, and with several other metallurgists who are well worthy of attention, and they do not believe that in ordinary grey iron of 2 to 2½ per cent. of silicon you have free oxygen present. That is a very debatable point, and there are great difficulties attaching to the detection, chemically, of oxygen. This line of work is very important, and may very well have more attention paid to it. As for the supposed results from the inclusion of oxides, I can believe oxide is present in the casting if it is badly skimmed; or if the moulder allows his runners to get down there must be oxide. But as regards ordinary castings, I do not see through this matter.

Mr. R. Mason: At the last Convention, I spoke about trouble with some brown spots. Mr. Houghton was reading a paper on analysis, and I mentioned about using ferro-manganese to make our irons closer grained. Mr. Houghton pointed out it was very likely due to the manganese that the iron was broken up by certain lines of demarcation. I had the manganese pounded into smaller pieces, and I have not had that trouble since. This time, another point has come up which gives me a good deal of information about these spots, spoken of by Mr. Stead and Mr. Munnoch. I was very much troubled on one occasion with a hard spot in a casting. The file would not touch it, and I could not understand this at all. I tried the casting, and all round the edges it was soft. I filed away until I got round about the piece which had the globule, and found it was extremely hard. We had not had that before, and I thought it was not likely to occur again. But it did crop up again later. I saw a casting that had just been cast, and it had a hole in it, and the hole was partly filled with the hard, white substance Mr. Stead talked of—a sort of strawberry. We had the core found, and discovered that we had been having a few blow holes at that place. No doubt, before the metal solidified, this substance was forced into the blow hole and filled it up. Mr. Buchanan says it is sometimes a good job to have these blow holes filled up somehow, but we don't want them filled up in that way. As to the use of borings in the cupola adding sulphur to the iron, Mr. Keep, of America, recommends it very highly. I wonder if the gain he speaks of is due to the increase of sulphur. He seems to think it is due to putting borings in. Mr. Munnoch, however, says it is the sulphur. He speaks also of using glazed irons. We see it continually stated that high silicon makes the casting more solid, and gives other advantages, and we find some foremen buying a dear iron and mixing it with Scotch. If this does not give good results, he goes and buys glazed iron.

and at last, by trying all kinds of mixtures, he at length gets good results. But if he knew more, he would be able to reach the same results with cheaper iron. The author says he has seen that shrinkage holes are often lower in phosphorus, and that is due to the silicon being drawn away. I have seen that myself. In the case of a casting with a heavy boss on it, you will see a greasy spot which will run away down into a hole. I think Mr. Munnoch's explanation is really the correct one—that there is not enough attention given to noticing the effect of higher temperatures. I must support him on that point; there is no doubt a large number of places where the furnace is not working as it should do, and takes up impurities, mainly sulphur, which it would not do if a sufficient quantity of coke were allowed. With regard to the advantage to be gained by adding scrap, in the way of reducing shrinkage holes, at a meeting in Birmingham, when Professor Turner was speaking, I mentioned that by adding scrap to certain irons that seemed soft I could always reduce the shrinkage holes. Mr. Cook, however, said that he found that by adding more pig-iron he could reduce it. Thereupon, Professor Turner said: "Oh, that is just the reason why you two should exchange pig-irons." It is a matter to find out what is the most suitable iron for your purpose, but I found that the addition of scrap often prevented this shrinkage.

Mr. G. M. Riches: One point I want to raise is: What proportions of other constituents are present? Have you any analysis of these highly phosphoric globules?

Mr. Munnoch: I can give you complete analyses.

The President: It will be given in the "Proceedings."

Mr. Caddick: There is one thing that has been especially emphasised in this discussion, and that is, we must exercise very great care in the use of analysis in the foundry. The various experiences, both of chemists and of foundrymen who have spoken, emphasised that fact. One thing I want to speak of is soft iron in regard to silicon. I followed very closely the articles written by Outerbridge, of Philadelphia, with regard to the presence of silicon. In my own shop, we had a trouble with some very small nuts which had to be made to fit into the interior of a vice. It is very essential that they should be very strong, and to be capable of being milled down to very fine points without having to be very severe on the cutters. By using soft iron we should get a weak iron, which was to be avoided. After reading Mr. Outerbridge's remarks on this question, I experimented as he suggested, but I found that instead of a softening effect it had a hardening effect. These castings weigh only 10 lbs. or 12 lbs., but I had the ferro-silicon dropped in gradually. My experience, however, was that it did not get thoroughly diffused, but you simply would get silicon in the middle, and that the other elements with 70 or 85 per cent. silicon were not affected. I then got down to 50 to 60 per cent. silicon alloy, and had it pulverised into very small particles, and I found that answered very well. We are making some thousands of these things a month, and we seldom get a hard one. They are suitable for machining, and, at the same time, sufficiently strong. This shows it is not desirable always to use a very high silicon. I should have liked Mr. Munnoch to have dealt rather more fully with the use of steel scrap. I find that unless you get hold of the right quality of steel borings you are likely to reduce rather than to increase the strength. Another point is to see that they are thoroughly melted and diffused.

The President: With reference to the question of chilling with iron inserted in the cores, it is a thing I have practised regularly in connection with bosses. I prefer it to borings. Boring must be very regularly done, or it is very detrimental to the casting. Where you have a lot of working with the vice, it is better, I think, to put in a chill.

Mr. Munnoch: I am afraid I shall not be able to say much in reply; but one thing which must be taken into account when considering cast iron is that different circumstances have a great effect. For instance, one person finds that a high manganese softens iron, another that it hardens it. Of course, that is due to a large extent to the circumstances under which it is applied. Mr. Cook says that sulphur is preferable to manganese for wearing surfaces. As a rule, with sulphur in large castings, if you have both sulphur and manganese present, the hardness is to some extent variable. You cannot be certain of it, on account of the difference in the temperatures of the metals contained. In the case of high-temperature metals, the sulphur tends to be eliminated, whereas, in iron of a low temperature the sulphur stops there and causes hardness. Now,

in small castings, high manganese, with high sulphur, undoubtedly hardens. That is, in small, thin castings. Of course, in larger castings, the effect is to soften. Therefore, it is preferable in large castings to harden by means of sulphur and keep the manganese as low as possible. The irons most useful for hardening, where hardness and strength are required, are usually lowest in manganese. There is another question in reference to crumbling—crumbling that is not due to manganese, but usually to the too-soft metal. Of course, the indirect effect of manganese may be to soften the metal, and, therefore, may cause that crumbling. The remedy then is a hard iron to start with. Mr. Buchanan says that in 99 per cent. of cases the composition agrees with analysis. I can hardly agree to 99 per cent., but I should say in, perhaps, 50 per cent. (Laughter.) When applying analysis, one often comes across very contrary tests. You very often find that circumstances alter cases, and it does not do to put too much reliance on one single analysis. In a general way, it is possible to trace and connect mechanical properties with a chemical composition. As regards the size of the graphite plates, and the difference in hot and cold-blast iron, Mr. Buchanan mentioned that the size of the graphite plates is smaller in the cold-blast iron. That is due to the smaller amount of carbon that is present. With the larger amount of carbon these graphite plates are larger, whereas iron low in total carbon usually has closer grain, due to smaller graphite plates. This is due to a great extent to the large amount of total carbon. With regard to the effect of manganese on the appearance of the metal, Mr. Buchanan said that as a rule the break altered with the amount of silicon. I have not found this to have any effect, because I am dealing with different irons, with a different amount of manganese. As a rule, we have found it is the manganese and not the silicon which affects the appearance of the melted metal. Of course, pig-irons which contain high silicon usually contain a high amount of manganese, and at the blast furnaces there is no need to judge the quality of the iron by the appearance of the metal caused by the manganese, because as the manganese goes down you can generally rely on the silicon going down as well. But you can have either a high or a low manganese with a high or low silicon iron and still get this effect on the appearance. The addition to alloys of 1½ per cent. of phosphorus and 2½ per cent. silicon very often may prevent sinking due to the removal of the oxide. High silicon iron, as a rule, is easily oxidised through the cooling of the mould. It is not the case with a very low silicon iron, and, therefore, it is quite probable that sinking will be reduced by the addition of any metal or alloy which removes the oxygen. As regards the addition of scrap to prevent sinking, this can often be accomplished by using a low quality of metal at the start, and the scrap is equivalent to a low quality of metal, being higher in sulphur and lower in manganese, and lower in total carbon than the average of pig-iron. With regard to the addition of brittle white iron to grey iron increasing strength, it is evident that this is due to increase in sulphur, and to some extent also to closing the grain. In addition to increasing the combined carbon, the addition of sulphur usually gives a smaller grain, which is much the same as making the iron into a lower quality, closing the grain, increasing the strength, as well as increasing the combined carbon. Of course, an excess of combined carbon decreases the strength by rendering the iron brittle. There is no doubt that iron is oxidised largely when it is melted at a low temperature. With iron of a low fluidity standing in the ladle, you can see the oxide and the graphite rising to the surface and forming a spongy mass, which is usually full of small shot holes. With refernce to Mr. Mason's remarks, he agrees as to these hard spots being caused by the use of phosphorus. On the question of using borings. Mr. Keep says it closes the grain without altering the composition. I have found that it usually increases the sulphur; it also lowers the silicon to some extent, and decreases the total carbon. Therefore, there is an alteration in composition which acts for the smaller grain. Mr. Caddick refers to the use of steel scrap in the shape of borings. That is unsatisfactory, because anything in the shape of borings is usually burned in the cupola and tends to the introduction of oxide in iron at this very high temperature and very high manganese.

The PRESIDENT: The paper we have just had is more or less of a technical character. We are now to be favoured with one wholly and purely practical. One of the chief features of our Convention is that we endeavour to combine the theoretical with the strictly practical

**Making a Propeller.**

FIG. 1.—BOSS AND BEDS.

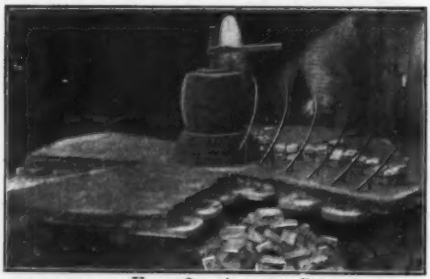

FIG. 2.—ANGLES SET.

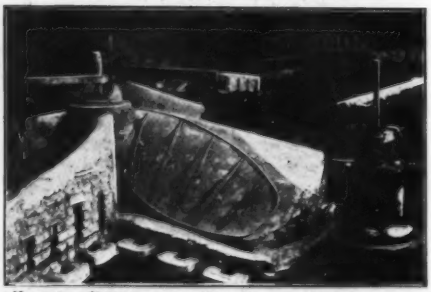

FIG .3.—BUILT, AND THICKNESS PIECES ON.

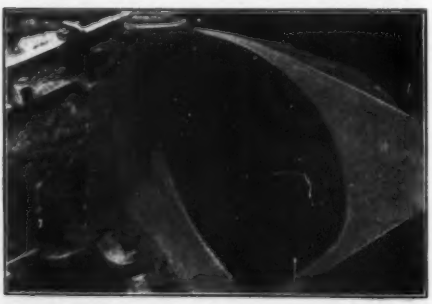

FIG. 4.—SAND PATTERN.

in our discussions, and to make all our proceedings turn to practical ends. (Hear, hear.)

MR. J. SMITH (of North - Eastern Foundry and Engine Works, South Shields) then gave a lantern lecture on

## METHODS OF WORK IN THE FOUNDRY.

The views shown by Mr. Smith numbered 37, and were all of actual foundry operations. In his opening remarks the lecturer said :—

Mr. President and Gentlemen,—I am not sure that I shall be able to interest everyone here this morning with the views I am going to show, and what I intend to say, knowing as I do that there are so many of you engaged in so many different classes of work. The views, however, illustrate our method of making large marine castings on the North-East Coast. It has always been interesting to me to visit other foundries. However small they may have been, I have always found something to learn in them. I do not say that I am going to show you the very best methods of making castings, but I hope that after I have finished my lecture, anyone who has anything better to show will tell us of it; and I for one, shall be very pleased to see it. (Applause.) The reason for my getting up this lecture was this : I had been urged over and over again by a friend of mine to give a lecture on moulding to the members of the Marine Engineers' Association. I have always found it difficult to explain the methods of moulding to men who have no practical knowledge of foundry work. In fact, after the trouble I had taken to explain the methods, I found they knew as much when I had finished as when I began. Engineers who go to sea, and men who build marine engines, know exactly what the engine should do, but how very few of them know how head-plates, cylinders, condensers, and other parts of the engine are made. (Hear, hear.) Therefore, I thought the best way to explain the methods of foundry work was to illustrate the making of castings, stage by stage, by means of the views which I am now going to show, and which are photographs of actual work in the foundry.

### Propeller Making.

Fig. 1. This propeller is made on a cast-iron plate not less than 1 ft. larger in diameter than the propeller, and mounted on wheels to run in and out of a stove or large oven. We first sweep the cup or bottom of the boss with a board

cramped on to centre-pin; we then sweep beds for angles to rest on, and build up the boss which forms the pattern.

FIG. 5.—TOP TACKLE.

Fig. 2 shows angles, which are made of light iron set on beds. Each angle has a centre mark on it, and is squared up from the centre mark on the bed. The moulder builds up to the top of the angle with loam and bricks, and strickles off with a straight-edge. This forms the bed or pitch of the propeller. It is then put into the stove for the first drying.

Fig. 3. The patternmaker then tries the pitch, and when this is found correct, marks out the shape of blades and sets on thickness pieces.

Fig. 4. The moulder then makes his pattern of sand, and commences to cover.

FIG. 6.—COVERED.

Fig. 5. Different foundries have different methods of covering the tops of propellers. Some use a cast-iron plate the full size, with prods cast on to carry the loam. Others have square holes in cross bars, and then shove up square cast iron to carry the loam and bricks. I have had experience in these methods, but find the methods that have been in use for thirty years are the very best for covering a propeller — by putting hangers over the cross bar and using wrought-iron slabs, so that you can always bend them to suit any pitch of propeller and always secure a good lift. We now cover the propeller and put it into the stove for second drying.

Fig. 6. We now lift off the top of the propeller, hang into jib cranes, remove the sand pattern, finish and black, place the tops on the bottoms again one brick high and put into the stove again for the third drying. The tops are placed in position, properly bolted and cramped down on the bottom plate, and cast in the open. There are many foundries where the propellers are lifted into large pits and rammed up before casting, but to my mind this is not necessary.

This casting, when finished and ready for the boring mill, weighed 5½ tons, and took 1 minute 5 seconds to fill.

FIG. 7.—PROPELLER FLOOR; 9 PROPELLERS IN PROGRESS.

Fig. 7. Propeller floor. It may be interesting to you to know that in the year 1906, 345 propellers were cast on this floor, and the total tonnage was 1,281 tons. In the year 1907, 414 propellers were cast, with a total tonnage of 1,510 tons, and there are now nine propellers in progress on this floor.

### Cylinder Cast Crown Down.

Fig. 8. This is not the usual way in which cylinders are cast, except for Government jobs, or special work to order; but it is a good and safe way to get a sound cylinder, especially on the crown. The bottom or crown of this cylinder mould is made of loam, and the body of sand. This bottom is built on a large cast-iron plate. The view shown is cast-iron machined out for the stuffing

box core to fit in. The crown pattern is then placed on and built up.

Fig. 9. The bottom of the mould is properly finished, blacked, and thoroughly dried.

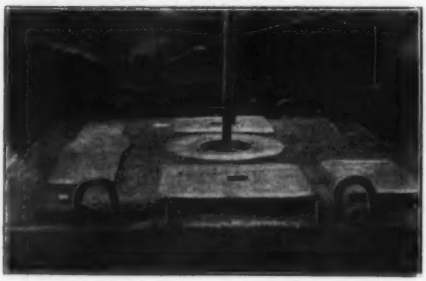

FIG. 8.— STARTING.

Fig. 10. The boss is then built, and this forms the barrel or pattern; it is then taken to the pit or case.

Fig. 11. The steam chest pattern is placed on one side of the box and the blank chest on the other, thus forming the full pattern in the pit.

Fig. 12. It is then rammed up with sand in the ordinary way. The ring shown at the top is a head cast on the cylinder to ensure its being sound.

Fig. 13 depicts the pattern drawn and the mould properly finished, blacked, and dried, and ready for coring. The height of the mould is 6 ft. 6 in.

Fig. 14. The cores are here shown ready for moulding. The steam chest on

FIG. 9.—CROWN OF CYLINDER.

the right is made in five parts; top and bottom, steam ways and exhaust are fitted into the steam chest, and then put into the plate or drawback face of the casting. The belt core running from the steam chest to the blank chest is fitted as shown.

Fig. 15 shows the top part on and the runners made up and ready for casting.

Fig. 16 shows the feeding head on top of the cylinder.

Fig. 17. The finished casting, weighing 9½ tons. The time occupied in filling with metal was 1 minute 25 seconds.

### Condenser.

Fig. 18. Before placing the pattern into the pit, sand beds are properly levelled for legs and feet to rest on. The pattern-maker then sets the pattern into proper position before the moulders commence operations.

FIG. 10.—BOSS BUILT ON CROWN.

Fig. 19. Rammed up to joints after the drawbacks have been placed on the top of the legs.

Fig. 20. The pattern covered and ready for the top part. It is then rammed up, grates and all tackle are properly fastened through bars, then lifted off.

Fig. 21. After the drawbacks have been removed, and the pattern drawn, the moulders finish their moulds.

Fig. 22. The top finished and ready for turning over to dry.

Fig. 23. Placing the main core in the mould.

Fig. 24. All cores in the mould and ready for the top part.

Fig. 25. The top part on, runners made up, and ready for casting.

Fig. 26. Casting.

Fig. 27. Cast.

Fig. 28. The casting, weighing 14½ tons, finished and ready for the engineer's shop. The time occupied in filling with metal was 1 minute 50 seconds.

### Burning or Mending Blades on Propellers.

Fig. 29. When any part of a propeller blade is broken off, and it is desirable to repair it, we first cut it straight so as to get a straight burn. That makes the contraction equal. We then place a plate underneath the blade of the propeller; put on one course of brick, and then a thin coat of loam, which forms the bottom part of blade, and then dry it.

Fig. 30. The templates for the thickness and shape of blade are placed on,

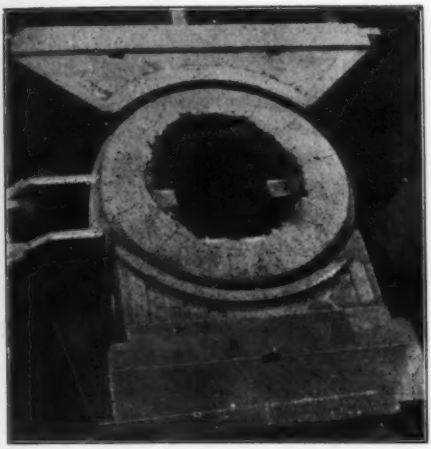

Fig. 11.—Pattern in Pit.

and the pattern formed of sand. This broken blade is 2 ft. long, and 2½ in. thick at the centre of the blade.

Fig. 31. The top is covered with a cast-iron grate, leaving a vacancy across the blade for the git, which will be $\frac{5}{8}$ in. on the cold metal and ¼ in. on the moulds. Then, after covering and drying, the top is lifted off and the sand pattern removed, finished, and blacked, and thoroughly dried before casting.

Fig. 32. Ready to burn.

Fig. 33. Properly burnt, and stopping up the git at the bottom edge of the burn.

### Lecturer's Remarks.

Summarising and commenting upon the subjects he had illustrated, Mr. Smith said :—

Fig. 12.—Rammed-up View of the Head.

In the metal foundry we have the loam moulding, green sand moulding, and dry sand moulding. Loam moulding stands distinctly apart from either green sand or dry sand moulding. The principles of all three systems are to a certain extent identical, but the materials employed, as well as the manipulation, are very different. We have every reason to believe that loam moulding is the most ancient method, both for brass and cast iron.

Of the three branches of moulding the loam is that in which the moulder can best show his ability. He has a broader field than the sand moulder in which to exercise his judgment, and, this being so, it is hardly fair to say that of necessity he is the superior man to the sand moulder. By no means; the one has greater scope for his ability than the

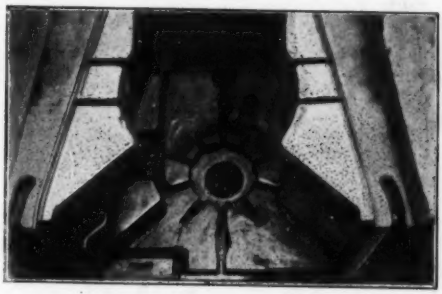

Fig. 13.—Mould Finished.

other, and the sand moulder has many more difficulties to contend with than the loam moulder, especially the green sand moulder.

There is a peculiarity about moulding upon which too much stress cannot be laid, namely, that a piece of work can only be done once, and if it is imper-

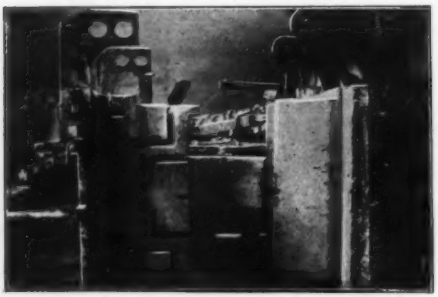

FIG. 14.—CORES READY FOR THE MOULD.

fect in any essential particular it is spoiled, and cannot be used for any other purpose, so that it must be broken up for scrap. There are a great many men in the engineering world who say there ought to be no bad castings. With this I quite agree; but there are very few men who come to the front to show us foundrymen how to make a good casting.

Engineers do not hold moulders in the highest esteem, but we think the reason must be their want of knowledge of the difficulties of the moulder's art, and the full importance of his work; for it must be borne in mind that by far the greatest weight of the metals used in the construction of machinery is cast iron. I

FIG. 15.—READY TO CAST.

also take this opportunity of pointing out that incompetent persons are sometimes appointed to examine castings, with occasionally the power of condemning them. It is sometimes laid to the charge of moulders—or, I should say, the foreman—that they hide the faults of castings. Now, although we strongly condemn this practice under all circumstances, we still admit a slight excuse for their doing so when they know that they are to be overlooked by an incompetent person, who may make a trouble about a mark on the surface from ignorance of its real nature and cause, but which affects the casting only in appearance. I may say here, there is a very small percentage of bad castings made considering the nature of the material a moulder has to work with, and I venture to say that if engine builders were to make their own castings the percentage would be even less.

### Burning Castings.

When any part of a casting has been broken off—such as a flange or tip of a propeller blade—the moulder considers

FIG. 16.—FEEDING AFTER CASTING.

whether he can mend this without injuring the casting. Mending, so as to ensure success, will depend wholly upon what part of the casting requires it. The formation of the casting has to be considered as well as the kind of metal that has to be used; and herein lies the danger of burning or mending. It is not every casting that will stand a portion of it being brought to a melting heat without splitting in some adjacent part; it depends almost wholly upon the formation of the casting.

When a casting is a bad one, owing to fracture, blowing part, etc., a moulder thinks it cannot be made worse by burning, which may as well be resorted to. Burning or mending a casting can only be done once on the same place; hence the necessity of taking every precaution before beginning.

It may be fairly questioned: Is a burn as good as if the casting had never been burnt? I at once answer (assuming the mend has been properly done, and there are no symptoms of a crack on the part of the casting) it is equally as good as if no burn had taken place. As examples may be taken the burning of large pieces on propeller blades; these propellers have been returned again broken on the same blade, but never near the burn. Therefore, from carefully watching the results of mending castings, my impression is that the mend, when properly done, is equal in strength to the rest of the casting.

It may again be asked: Would the burning have any evil effect on any other

FIG. 17.—FINISHED CASTING, 9½ TONS.

part of the casting, even a considerable distance from the mend, and thus, when the working strain is put upon the casting, cause the part to give way? In answer, I would say that this may, and even does, take place in castings of certain structure, such as bed-plates, condensers, cylinders, etc., in which it is difficult to determine on what part of the casting an undue strain may take place, owing to a portion of it being brought to a melting heat, cast iron being of such a nature that it may be on the point of flying, and no one be aware of it. But in plain castings (and especially when the mend is at the extremities) I scarcely think that burning has any vital effect upon the other parts.

Again, burning a casting on the middle parts should never be resorted to unless it cannot be mended otherwise, as it is seldom a success.

FIG. 18.—PATTERN IN PIT.

## Foundry Management.

The person who has control over a foundry ought to possess many qualifications. First, he should be able to manage or control himself. He ought to be thoroughly conversant with the work in all its branches that has to be carried on under his direction. A man who is continually losing control over his temper soon ceases to be respected by his subordinates, and in proportion as he does this he loses control over them. A man will at times lose his temper, but it ought to be as seldom as possible, and then only when he has a just reason. He should be a competent workman in every detail; able to know whether a man is working or frittering away his time; able to discern what a man really can do, and place him at the kind of

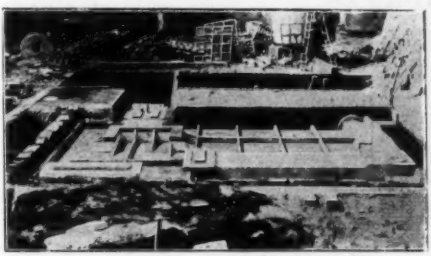

FIG. 19.—RAMMED-UP TO JOINT.

work he is suited for; able to discern the character of a man, and to know when he is working cheerfully or the reverse; able to read his men and shop like a book, from the youngest apprentice to

the oldest journeyman, and to tolerate no shouting or undue noise. He ought to be a sober man, and should also see that every man under his charge is sober during working hours.

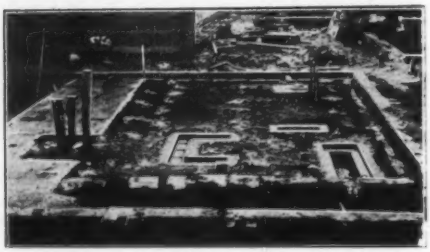

FIG. 20.—READY FOR THE TOP.

Familiarity breeds contempt: the foreman's distance from the men ought to be such as to promote respect, and yet not so much as to preclude them from speaking to him. He ought always to be able and ready to assist and encourage anyone who has got into difficulties with his work, providing that such difficulties have arisen from errors of judgment. He should evince no partiality, and show no favour, treating every workman alike. He should be capable of judging for himself, yet not be above taking a hint even from a labourer. In this he should fear neither master nor men, as they are both quick at detecting anything of that kind, and neither party is slow to take advantage of it.

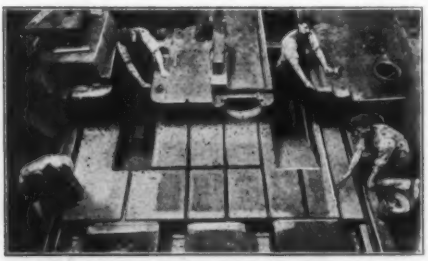

FIG. 21.—FINISHING THE MOULD.

## DISCUSSION.

The PRESIDENT: Gentlemen, we have been treated to a paper that for pure practical interest is almost unique. We have been able to trace the iron casting from the commencement to the finish. When people allow you to go through their works they don't show you everything—often because it is not possible to do so. Here we have seen everything, and in such a way that we have been able to understand and to be interested and to learn.

MR. BUCHANAN (referring to Mr. Smith's description of a cylinder cast crown downwards): Does Mr. Smith make and difference in the diameter of the bottom and the top?

MR. SMITH: We usually make about three-sixteenths of an inch difference, otherwise the pressure of the metal would nip the core a little. We always make the bottom of the core three-sixteenths bigger. For the upside down cylinder we don't make any difference, but for the open end down we do.

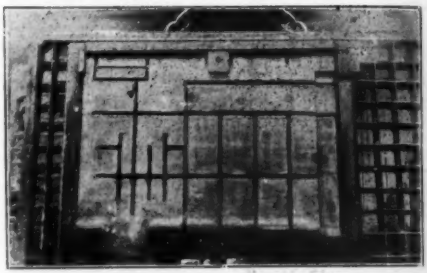

FIG. 22.—THE TOP FINISHED.

MR. LAURIE (Paisley): This branch of work is a very interesting thing, and Mr. Smith's address has brought it before us in a most interesting and helpful way. (Hear, hear.) Of course, in the case of a cylinder made inverted in the usual way with the crown downwards, there ought not to be any difference made. But I understand that it was not at Mr. Smith's desire that he made the cylinder crown downwards.

MR. SMITH: No, it was thought of by two or three of us. It is perhaps eight or nine years since we first made these cylinders crown downwards. We found we had trouble, particularly with cylinders that had to stand a very big pressure, and it was decided to try one the other way, and we found it to be a success. In fact, for one firm we never make a high-pressure cylinder unless it is cast crown downwards.

MR. LAURIE: There is another ques-

tion Mr. Smith refers to, and that is, the difference between the cost of making a loam job and a dry sand job. Provided you get the right pattern you can make the sand job with a total saving on the whole transaction if the foreman pattern-maker tries to turn out his job properly, but with the kind of patterns we get in the West of Scotland it is difficult—we frequently get them more in the form of orange boxes. (Laughter.) It has been proved without a doubt that with a pattern like this the moulds can be made much quicker in loam. We have held competitions, one part being sent to the dry sand end and the other to the loam end, and we have found that the loam moulder turned out

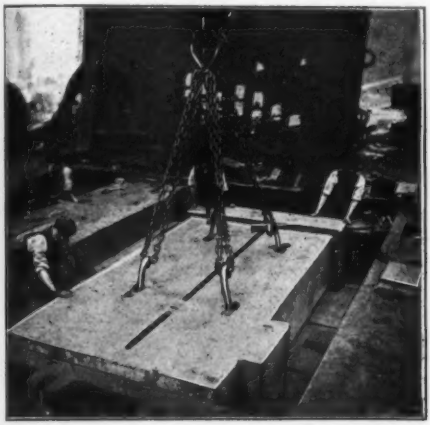

FIG. 23.—PUTTING IN THE CORES.

his job much quicker than the dry sand moulder. We have seen the same patterns sent to the dry sand moulder and to the loam moulder, and we have got the better results from the loam shop. Mr. Smith's method of making propellers is very interesting. That work seems to be a speciality in this part of the country, but I do not see the same precision in Mr. Smith's method as in the ordinary orthodox method. We are visited by the draughtsman with his pitchometer, and if he finds the slightest variation we hear of it. You must, at least, have a good surface on the underside of the propeller, and that is not so easily done with small sweeps. But the most suitable method to me is Mr. Smith's method of covering up his propellers.

MR. SMITH: I have had experience in making castings from skeleton patterns, and in my opinion you cannot make a casting either as correctly or as quickly in sand as in loam. Of course, you may

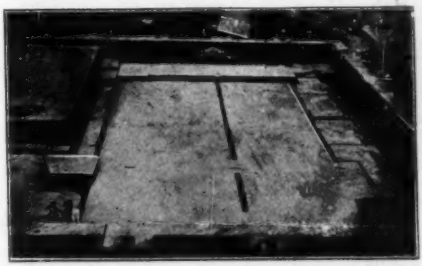

FIG. 24.—ALL CORES IN PLACE.

spend a fortnight over a condenser skeleton pattern to make a sand mould, while it would take only a week in loam; the amount of ramming-up with a skeleton pattern is easily seen. We have a man in the pattern-shop who can set up a propeller in an hour and a half, and it can be set up correctly. Most of them are tried, and we find they come out satisfactorily. We made a 17 ft. 6 in. propeller with two blades, commencing one night at four o'clock. It was put into the stove at half-past ten, brought out again next morning at four; it was marked off, covered, and in by twelve noon. It was brought out again at seven, put in again at eleven (the same day), brought out again at ten the next morning, and was cast at four o'clock in the

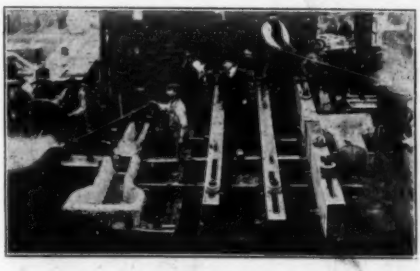

FIG. 25.—READY TO CAST.

afternoon. (Applause.) That propeller weighed 9 tons 5 cwts. Sometimes, in getting "our bar," a little bit drops off, and then we have to get to

FIG. 26.—CASTING.

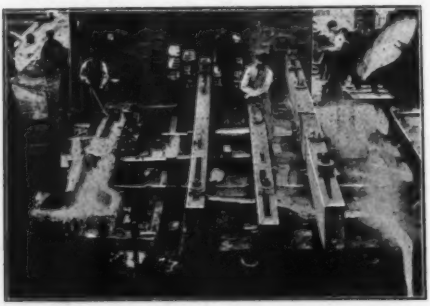

FIG. 27.—CAST.

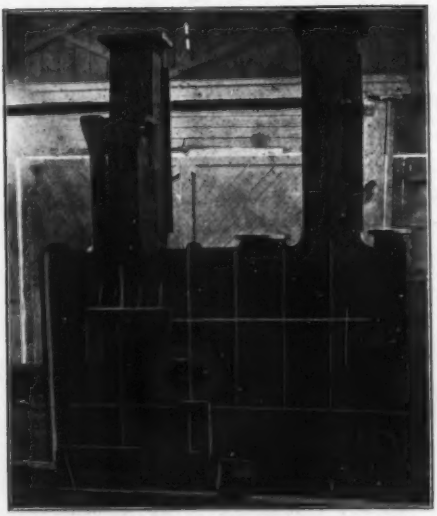

FIG. 28.—THE FINISHED CASTING, 14½ TONS.

work and burn another bit on. As regards the actual life of a propeller, apart from accidents, that depends greatly upon the water. Some go a long time, and are never pitted; but the ends of the blades are sometimes pitted very badly.

A MEMBER: If you had a jacketted cylinder, would you cast it in the pit in the same way?

MR. SMITH: We make a business of jacketted cylinders. We never think of making a cylinder in loam if we can make it in the pit. If we decided to make that in loam it would mean 20 tons of tackle.

The PRESIDENT, on behalf of the members, thanked Mr. Smith for his lecture, and called on Mr. Riches to read his paper, which was as follows:—

## THEORY AND PRACTICE IN THE FOUNDRY.

When asked to submit a title for a paper to be read at this meeting I had forgotten that Mr. Longmuir had given a splendid paper under this same heading, but as we are not likely to clash to any great extent I have stuck to this title.

Whilst scientific subjects can, and do, take a prominent part in practical foundry work, and are admittedly highly valuable, yet I venture to think there are some of us, who, through not having had the advantage of a scientific training, would prefer to have some of the smaller problems brought out and commented upon occasionally, and, further, I believe it would be to the advantage of our Association to keep this in mind. The purely practical foundryman should be catered for, and encouraged to meet with the purely scientific to the advantage of both. Good practical men are met who say the Association is not of much use to them, because they cannot tackle the advanced theories, and whilst we admire and highly value our scientific friends and their help, yet I feel sure they are broadminded enough to bear with a fair sprinkling of the practical, and, I trust, do all they can to point out remedies for our troubles, remembering that under the best possible conditions the foundryman's lot is no paradise.

That theory and practice do apparently disagree, in the foundry business more particularly, is owing undoubtedly to the complexity of the materials with which we have to deal, combined with the peculiar character of our work. We may not be the only class of workers who watch with anxiety the subsequent operations on

**Burning a Broken Propeller Blade.**

FIG. 29.—BROKEN PROPELLER BLADE.

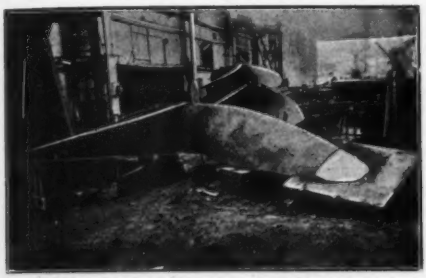

FIG. 30.—MAKING THE MOULD.

FIG. 31.—COVERED.

FIG. 32.—READY TO BURN.

their productions, but, the very fact that we do so on all jobs of importance, even when they have to all external appearances been perfect, proves the uncertainty which hangs over us like a cloud. And even where the most scientific methods have been adopted the same conditions exist, though, perhaps, in a lesser degree. If we admit that these conditions do exist, as I am afraid we must, then our industry is as yet in a very imperfect and uncertain condition, and until we can obtain a better knowledge of the materials we use, I am afraid we shall have to be content with slow progress, but even this should be an incentive to persevere.

We are all familiar with the unpleasant experience of seeing, if not a waster, a very indifferent piece of work turned out, after having provided the surest tackle, best materials, and given full instructions to a good moulder. We have seen a piece of sand shift and form an impression where it was not wanted, say, perhaps, because it was loosened in drawing the pattern and not fastened back; perhaps a scab was caused by the rammer being used too close or too hard, or the sand a little too close, too rotten, or too wet; or, perhaps, the vent wire was improperly made use of. We have also seen a moulder, who is very careful to prick every part of his mould, then roll it over, and block most of the vents by rubbing hard down on an improperly made bed. He uses a vent rod under his mould, but that does not meet the others by perhaps 2 in. or 3 in. The depth of a sand bed should be dug up to correspond with the area of the mould; for a mould 3 ft. by 3 ft., say, not less than 3 in. deep, and for 6 ft. by 6 ft. not less than 6 in. deep, and made even so that little rubbing down is required.

I had some years ago a case of this vent blocking, on what is considered by some to be very common work—that is, grate bars. The sizes were 24 in. diameter, made in five sections, with ½-in. bars and ½-in. spaces, and 4 in. greatest depth. When the time came for casting these, it was no uncommon thing to see fireworks, with an occasional burn and plenty of wasters. Eventually, suitable flasks were made without bars in the drag, but instead loose plates full of holes were cast and used as follows:—The drag, being open, was quickly rammed and strickled, then the plate was clamped on and the whole rolled over on to rails fixed about 12 in. above the floor, and so cast. Afterwards they were finished in the usual way. This successfully got over

the trouble, and it is now a very rare thing indeed to see a blow-up.

So much for practical venting. Of course, much more could be said on this point, and I believe the principle just mentioned, might, for standard work, be carried out with advantage more than it is. I have three other jobs being worked in a similar way, two with drag bars and no plates, and another without drag bars, plates being used.

This brings us to sand. Sometimes, after figuring out a mixture of sand, which for a length of time works satisfactorily, we suddenly find a large percentage of the castings scabbed, unsightly, and some, perhaps, useless. The trouble is eventually, but too late, traced to the sand mixer, who has milled his mixture more than usual.

FIG. 33.—BURNING IN PROGRESS.

Being situated a considerable distance from any known sand beds of a suitable character for making good castings, I have tried various mixtures for facing, some of which were composed of many ingredients, such as three or four different sands, coal, horsedung, sawdust, meal, gum, ashes, road-scrapings, yet although most of the mixtures worked satisfactorily for the class of work they were intended for, I have come to the conclusion, that although the materials may come cheaper by working in a local sand, the extra labour involved in mixing and keeping stocks is a set off against it. I think there is not anything at present to beat a simple mixture of old floor sand and coal with a new sand of a similar grade to that found at Worksop, which in colour is dark red, and fairly coarse grain. Three parts new, three parts old, and one part coal, if properly mixed make a very good, medium strong facing and should turn out clean castings. Some years since I heard of a patent process for renovating old sand, so that none or very little new sand should be required; but the foundry that I knew to be using this process, I have good reason to think, has discontinued to do so.

Some of our troubles are difficult to explain straight away. On certain work, of a green sand plate character, where a blistered surface appears, we may be certain that it is the result of the sand being too wet, or too hard rammed, or insufficiently vented or steamed, so that the metal on entering the mould boils as it does in a damp or hard ladle, but which of the three causes named is responsible for the result it is impossible to say, not having examined the moulds previous to casting. It might be either one, or a combination of any two, or the whole three. A case of cores scabbed came under my notice some time since; it was not difficult to say that the sand or the core-maker was at fault, but which? I tackled a few of the cores myself, using the same sand in the same way, with the exception that I made them in half the time, and although I used different coatings of blacking, they all turned out perfect. This proved that the sand mixture was right, and that the core-maker had been taking too much time and ramming too hard. I can call to mind other jobs where the time has been reduced, and the castings turned out at least as good as before. In each of these cases it is not in the theory, but in the want of commonsense that the fault lies.

What appears to me to be required, more particularly for work that calls for a high degree of finish, is some substance that could be used in a pasty condition to form the mould, either by being poured around the pattern, or packed against it by hand, and which would immediately take to itself a certain amount of set or firmness, similar to Paris plaster, in order that the pattern may be withdrawn. In connection with this some suitable coating would probably have to be used on the patterns. If we ever get a material of this description it would probably have to be dried, and in order to facilitate rapid work it should be one that would stand rapid drying without cracking, disintegration, or alteration of shape, and be sufficiently porous to require no venting. Some may say this is a tall order, others that it is a case for loam moulding, but loam moulding is too costly and too slow, not meeting the case by setting quickly so that the patterns may be with-

drawn. This is one poser I wish to leave with our scientific friends, to see what they will do for us.

The new patent chill-casting process, by Dr. Szekely, may do for repetition work, but I am not so sure that it has any advantage over the modern multiple moulding machine for iron or steel castings, owing to the deterioration and consequent renewal of the matrix under high casting temperatures, but there is no doubt but that a great deal more could be cast in chills to advantage than is at present done, more particularly with brasses and bronzes. I think we are all familiar with the fact, that apart from special coatings, ordinary chill casting is nothing new; for my own part I have been acquainted with it in some form or other since I was thirteen years old, but it is obvious that it will never meet the case I have just put before you, of castings required in small numbers.

Now for theory and practice in connection with analysis. Mr. Longmuir, last year, dealt at some length with silicon and micrography, so these I may conveniently pass over. In working up mixtures to analysis, I have found it very awkward when the elements are sometimes stated in one order and sometimes in another, and I am afraid this has sometimes been the cause of mistakes. What I want to see, and what I think we as an Association, should endeavour to bring about, is, that the different elements in cast iron should always be quoted in some recognised order, in lectures, papers, periodicals, and the technical and scientific Press. I would suggest the following order:—G.C., C.C., T.C., Si., S., P., M., I. I purposely include total carbon because I have good reason to believe that it will play a much more important part in future figuring than at present. Let me give one case in support of this statement. Now that the engine-builder is getting accustomed to steel in its various phases, he puts the same to considerable strains, and expects cast iron to stand much more than formerly. When searching for some mixture that would show a good deflection with considerable hardness, I noticed that the dark grey high carbon irons, while always increasing the deflection, reduced the ultimate strength, providing the silicon was kept about 1.50. I believe that to get the highest strength of a mixture that will show a good, bright wearing surface, with a fair hardness and a medium deflection, we shall have to work with the total carbon some points below 3 per cent., and silicon about 1.5.

As I have just referred to what I call my compound test, I will give a short description of it. In size the test bar is ½-in. square by 2 ft. 4 in. long, cast in green sand, in a narrow box, with the ends touching the inside of each end. The odd 4 in. are there because the boxes happened to be this length. This gives me three results, namely, contraction, deflection, and chill. The contraction is obtained by measuring the difference between the lengths of the bar and the box; the deflection is found by placing the bar between two points and a centre screw, and counting the number of turns of the screw given between the touch and the break of the bar. The depth of chill is found by splitting the ends with a chisel.

This forms a simple, inexpensive, yet valuable test, more particularly for work of the nature of spring piston rings.

For the benefit of any who have not tried it, I may say that the percentage of total carbon may be conveniently reduced by melting from 5 to 10 per cent. mild steel plate scrap with the iron; by this means the percentage of pure iron is increased, and consequently all other elements reduced. Scientific investigators, notably Mr. Arthur Hiorns, in a paper before the Staffordshire Iron and Steel Institute, have at different times given us the effect of certain elements on other elements in cast iron. But so far it appears to me the question is only just began; a much greater field requires to be covered before we arrive at the point where we can say that a certain analysis gives the best results for any particular casting. I venture to say that no one can give with any degree of certainty the analysis of an iron that is most suited for, say, fire-bars, but undoubtedly there is some particular mixture that would stand the greatest heat, and consequently give the longest life. Or, to take another line, what combination of elements is best adapted to withstand the corrosive action of sea water? Although we are to a large extent a maritime nation, yet I believe I am right in saying that nothing definite is publicly known in this connection with a most important branch of our industries. We have various bronzes made up of different alloys and a considerable amount of knowledge is disseminated anent these materials, but not cast iron. Further experiments should be carried on by adding different proportions of each of the elements, until all the usual elements found in cast iron are there, because I feel con-

fident that there is some law governing the complex relations of the various elements to give a definite result. This would be a very important work, the value of which would be enormous if it could be carried to a scientific conclusion. I beg to ask our Council to consider the advisability of providing means for this invaluable object, because, the successful manufacture of iron castings resolves itself into about three essential conditions —a suitable matrix or mould and a suitable iron properly melted. This brings us to another point where theorists disagree amongst themselves. Some writers tell us of oxides being formed in the cupola, others will say this is very improbable in a bed of incandescent coke, while others give an answer conditional on the size and position of the tuyeres. I quite believe that these latter play an important part, but for small and medium sized cupolas I recommend simplicity. The cupola I am now using was started with four bottom tuyeres 12 in. above the sand bed, and having an area equal to one-seventh of the melting zone, which gave satisfactory results. Afterwards three small upper tuyeres were added, which addition was no apparent improvement, and is not now used. Experimenting further, two of the four tuyeres were closed, this gave better and quite satisfactory results in hotter metal and considerably less attention required during casting and fettling after each cast, the two tuyeres keeping clear much longer than the four did, requiring attention about three or four times during a three hours' run. I should say that the blast pressure is about 10 ozs., and melts iron as fast as can be conveniently handled. But as to metal being oxidised, I, too, have got a theory, and it's this— That where sufficient coke is being used, say, 1 to 8 or 10, according to circumstances, there is not much reason to fear oxides, but where the melting is carried on under such high ratios as 1 to 15, one should not be surprised to find that oxides exist, perhaps other things as well. On the other hand, we should equally guard against using more than enough coke, as this also does harm, retarding the melting and adding more sulphur to the iron. But a mere statement of opinion should not be sufficient for us; I should like to have it proved that oxides do or do not exist to any appreciable extent in metal melted under proper conditions, and if one of our friends who has the appliances and the opportunity could do this it would be another step in the right road.

Another controversial question is the method of gating and running important castings such as cylinders, liners, etc., in their various forms. Some will stand by dropping the metal right down from the top, whilst others say the only way to get them sound is by gating at the bottom. I have tried both ways, and find that good and bad castings can be made by either way. As I previously said, so much depends on the human element. I am positively sure of one thing, that it is very difficult to get moulders to consider the runner or gate as a very important part of the casting.

### President's Concluding Remarks.

The PRESIDENT: No doubt, gentlemen, you are perfectly agreed with Mr. Riches when he says that most of our papers should be of a practical nature. That we have not had more of such papers has not been the fault of the Council; we have been able to get hold of scientific papers more easily than we could practical papers, as a rule. But we have tried to make our meetings more and more practical, and gradually we are succeeding in getting more practical papers read. No doubt when Mr. Riches' paper is printed we shall gain much from perusing the results of his experiences. As the time is so late we shall not have time to discuss it, but if there is any point in it on which anyone has anything to communicate, he can write to the Secretary, and he will deal with the matter.

This concluded the discussions of the Convention.

The PRESIDENT: Gentlemen, we cannot break up without proposing hearty votes of thanks to those who have allowed us to meet here; also to the local committee who have been so kind as to make all the arrangements, to the gentlemen who have read papers, and to all who have helped to make this meeting a success, not forgetting those firms whose works we have visited and are to visit, and the authorities of Durham Cathedral, which we are to visit to-morrow. (Hear, hear.)

MR. FINCH seconded the votes of thanks, and these having been heartily agreed to, the second day's Session ended.

### Visits.

In the afternoon the members, to the number of about 50, crossed to Gateshead, where they visited the works of Messrs. Clark, Chapman & Company, and Messrs. Scott & Mountain. The evening was

spent by many in Jesmond Dene, the lovely glen which forms part of the Armstrong Park, one of the many generous gifts of the late Lord Armstrong to Newcastle-upon-Tyne.

On the Thursday morning a large party travelled to Jarrow to visit Palmer's famous shipbuilding yards. The Convention, on its social side was brought to a pleasant close by a visit to Durham to view the Castle and the Cathedral. At the latter place the visitors were received by the Dean.

This concluded the annual Convention of the Association.

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## BY-PRODUCT COKE FOR THE FOUNDRY.*

By Geo. A. T. Long.

The requisites for a good foundry coke are—first, high carbon; second, low sulphur; third, good cellular structure; and, fourth, that the product shall be uniform. The carbon and sulphur are primarily the result of the quality of coal which is used in the ovens for coking purposes. The structure, however, depends upon the proper preparation of the coal before coking, and also upon the arrangement of the oven in which the coal is coked and upon the temperature of the coking chamber. It does not, therefore, follow that all by-product cokes are necessarily good foundry cokes, any more than that all bee-hive cokes should be equal to Connellsville. There are, however, certain plants of by-product coke ovens which have made a specialty of manufacturing coke for foundry purposes, and have given special attention to the selection of their coals, and they are producing a coke which contains all of the qualities which go to make up a desirable coke for foundry purposes. There are a number of other plants of by-product coke ovens at other points in the country which are manufacturing coke for blast furnace or domestic use. Coke from these plants, where the coals have not been carefully selected has sometimes been bought by foundries, with very unsatisfactory results. You would not buy any beehive coke which was offered you, without ascertaining whether it was especially adapted for foundry purposes, and you should not, therefore, buy retort coke simply because it is retort coke, but should know before taking it into your plant that it has been produced by a manufacturer who understands the requirements of the foundry trade and is known to be producing a standard foundry article.

According to my experience in conducting tests with by-product coke made especially for foundry purposes, it will carry more iron than any other coke in the market. Why? Because it has the structure, is high in carbon and low in sulphur. We all know what an enemy sulphur is to iron. How often have we had to change our mixture or add an alloy when we got a car of high sulphur coke, in order to produce machinable castings?

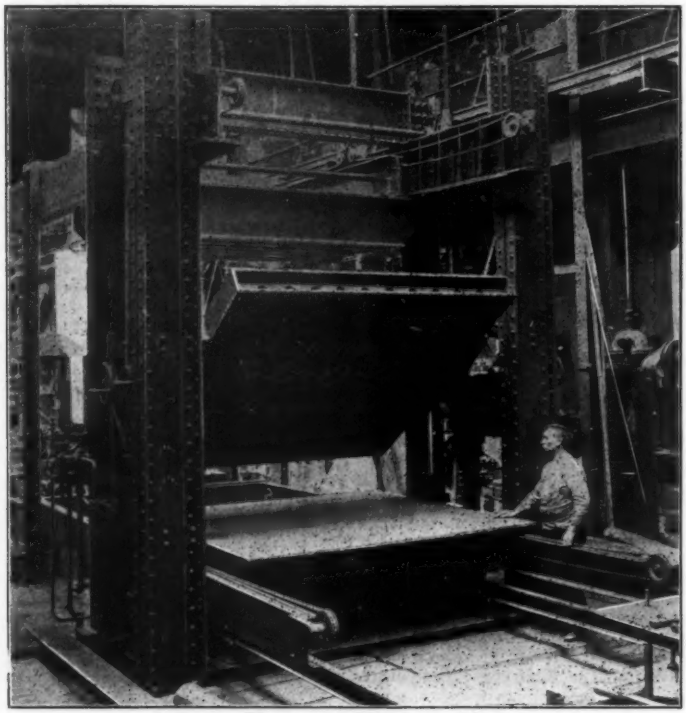
I claim that by-product foundry coke, produced in the desired manner, will give better results with all kinds of iron melted in a cupola, either for stove plate, machinery or car wheels, high or low carbon irons. Car wheels require more coke to melt than stove plate or machinery, owing to the use of low carbon irons, and more carbon has to be supplied to the metal; for a mixture going into the cupola is 3.20 in total carbon, and a wheel should contain 3.50 to 3.55 total carbon, so the difference must be supplied from the carbon in the coke. Therefore, the higher the carbon in the coke the less fuel it takes to melt the metal and the better the casting will be.

I was called a short time ago to investigate a little trouble at a certain plant in the West. On reaching the plant I found that they were using the same iron continually, had not got any new iron in five months, and knew the analysis of every car on the ground. They were using 6,000 lbs. of iron to each charge and 720 lbs. of coke, before their iron would be fluid enough to run their castings, but had trouble in the machine shop. They were using a Connellsville coke which stood 0.98 sulphur, 83.00 fixer carbon, 13.00 ash. While I was there they received a car of by-product foundry coke, which ran 0.54 sulphur, 91.00 fixed carbon, 7.23 ash. After starting this coke going I had to cut down after the bed charge to 600 lbs. to each charge of 6,000 lbs. of iron. I also increased the scrap 15 per cent., which made stronger castings and remedied the trouble in the machine shop. In this case, the charge of 720 lbs. of Connellsville coke contained 7.05 lbs. of sulphur and 597 lbs. of carbon, while the charge of 600 lbs. of by-product coke contained 3.84 lbs. of sulphur and 546 lbs. of carbon, approximately half the sulphur and only 50 lbs. less of fixed carbon, although using 120 lbs. of coke less per charge.

* Read before the American Foundrymen's Association.

## LARGE HYDRAULIC MOULDING MACHINE WITH REVOLVING PATTERN PLATE.

The last few years have seen increasing claims made on the capacity of machines and tools, with the consequence that great strides have been made in their perfection. As an instance may be mentioned the introduction of high-speed steel, as well as the increasing size and power of machine tools.



A Large Hydraulic Moulding Machine.

The same strides have been made in the perfection of moulding machines. Until within recent years it was thought that only small castings with simple outlines could be produced economically on moulding machines; but this has now been proved to be erroneous, and at the present time quite large and intricate castings are produced economically on moulding machines.

The illustration shows a large machine for heavy steel castings, which has been supplied by the London Emery Works Company, of Park, Tottenham, London, N., to a large steel foundry in this country, for the unusual size of moulding boxes of 7 ft. by 7 ft. As will be seen from the illustration, the machine is of the turn-over type; that is to say, it is fitted with a revolving pattern plate, which is arranged to carry one-half of the pattern on each side. The turning of this large pattern plate fitted with the necessary moulding boxes filled with sand is done expeditiously by one man, as also is the movement of the rammer head and bottom carriage. The moulds are rammed with one squeeze by hydraulic power, which is also utilised to draw the pattern.

Some idea of the size of this machine—which we believe is one of the largest, if not the largest, power-moulding machine ever constructed—can be obtained by comparison of the following details:—The size of boxes is 7 ft. by 7 ft., and the net weight of the pattern plate 3 tons. The total net weight of the machine is 30 tons, the total height 18 ft. 6 in., length 19 ft. 3 in., and the width 13 ft.

## DRAWING FOR PATTERNMAKERS ROOF WORK.

In practical foundry work there are many problems which arise in its ordinary course, which, if the workman is not conversant with the information necessary for their solution, may add considerably to the cost of the work.

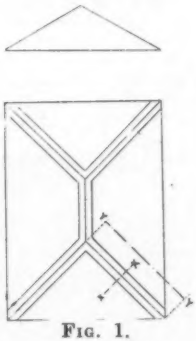


Fig. 1.

The branch of trade to which it is proposed in this article to direct attention is that which is associated with architectural work, and has special reference to roof work. To deal successfully with roof work the patternmaker must have a knowledge of geometry, which is the basis of architectural drawing, no matter to what particular branch of the trade he may belong.

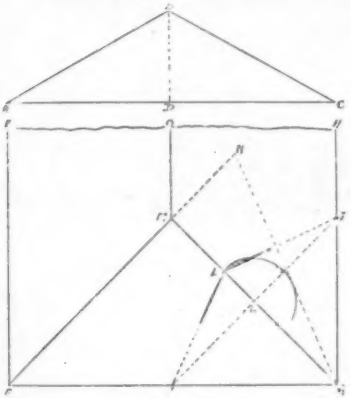


Fig. 2.

Let us first consider a class of work which, within recent years has shown marked development, namely, roof flashings, known as ridge and hip plates. These are used for weathering those parts of a roof where the slates or other covering meet at an angle.

With lead and zinc the trouble which meets the ironfounder does not exist; owing to the pliability of these metals they can be bent at site to suit any angle. The case, however, is different with cast iron, as the various angles the work has to suit must be accurately determined.

There is no difficulty in determining the angle of the ridge plate, as the rake of the roof, or its width and rise, are always given.

It is with the hip plate that the trouble occurs.

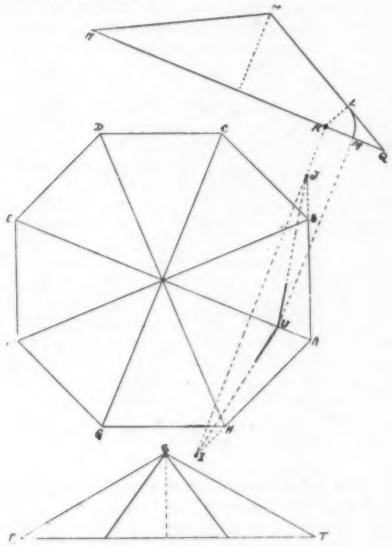


Fig. 3.

Making the pattern often is simplicity itself, compared to the details which lead up to that point where the actual construction of the work starts. With the roof, shown in Fig. 1, it is required to find the angle of the hip at the point marked X X, and the true length of the hip plate marked Y, Y.

It is, of course, not necessary to draw the work to full size when the angles only are required.

Fig. 2 shows the method of finding the angle through X, X, and the total length of the hip Y, Y. Let A, C be the width or spread, and D, B the rise of the roof, of which E, F, G, H represents part of

the plan, M, O part of the ridge, and M, F and M, G the hips.

Draw M, N equal to D, B at right angles to M, G, and join N, G.

The length N, G is the true length of the hip between the points marked Y, Y on Fig. 1.

Now draw a circle, the centre K lying on the line M, G and the circumference touching the line N, G. Draw a line passing through the centre, K, at right angles to M, G, meeting G, H at J and G, F at I. Join J and I to L at the point where the circle cuts M, G, and the angle I, L, J is the angle through the hip marked X, X on Fig. 1.

To this angle the pattern for the hip plate can be made, and when placed in position will be found to lie flat on each of the two adjacent slopes of the roof.

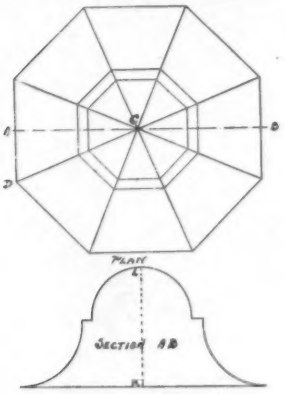



FIG. 4.

Now let us consider the method of finding the true length, and the true angle of the hip of a roof, the plan of which is a polygon, such as the roof of a bandstand or other similar work.

Let R, S, T (Fig. 3) be the elevation, of which A, B, C, D, E, F, G, H is the plan, and N, P, Q a section through E, A. Produce A, B to J and A, H to I, making A, J equal to A, I. Join I, J and produce it till it meets N, Q at K. Now, from K draw K, L at right angles to P, Q, and with K as centre and K, L as radius draw the arc L, M. From the point M draw a line at right angles to and meeting E, A at U.

Join U, J and U, I, and the angle I, U, J is the required angle through the hip of the polygon, of which R, T is the spread and S, V the height.

The example selected is an octagon, but any other polygonal figure may be worked out in the same manner.

The foregoing applies to straight roofs only.

When the roof is ogee in shape at no two points is the angle through the hip the same, therefore, the angle for each part must be worked out independently, but as the treatment is similar to that already described it need not be repeated.

In ogee and other irregularly shaped roofs the outline of the hip often gives some trouble, but may be found in the following way. Let us take as an example the roof of a bandstand, of which Fig. 4 represents the plan and section.

It is required to find the true outline of the hip, so that the roof astragals may take their correct form.

Draw to full size a half section through the flats (see Fig. 5), making E, F equal

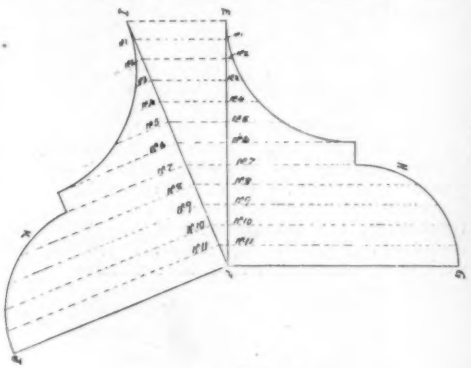


FIG. 5.

to A, C (Fig. 4), and F, G equal to K, L, the height of the roof, G, H, E being the outline of the roof. From E draw E, I at right angles to E, F, making I, F equal to D, C (Fig. 4).

Now divide E, F into any number of parts, and from these points draw lines at right angles to E, F till they meet the outline G, H, E. Number these lines as shown in Fig. 5 and produce them till they meet the line I, F. By this operation we divide the line I, F into the same number of parts as E, F.

Draw F, J at right angles to I, F, making F, J equal to F, G, and at the points on I, F erect lines of corresponding length to those erected on the line E, F.

If the ends of these lines be joined we have the required outline of the hip, as shown by J, K, I on Fig. 5. No matter what may be the plan or shape of the roof, if the foregoing rules be adhered to a correct delineation of the roof will be obtained.

## THE "ARDELT" PIPE MOULD RAMMING MACHINE.

For many years attempts have been made in pipe foundries to abandon the usual method of ramming the pipe moulds by hand and to introduce machine-ramming instead. In 1850 the first machine of this kind was patented in England, and many others followed; for every foundryman was keenly alive to the fact that by the introduction of machine work a considerable economy in the cost of production would be effected. Unfortunately, however, the result of all these efforts was by no means satisfactory. Hence, at the present time only a

FIG. 1.—THE "ARDELT" PIPE MOULD RAMMING MACHINE.

comparatively limited number of pipe foundries are provided with ramming machines. One of the reasons for this is that the machines are not capable of ramming the moulds for pipes of all diameters. The purpose of the present article is the description of the Ardelt patent pipe mould ramming machine, which is in successful operation in many foundries of Germany, Austria, and Belgium, and which is claimed to be practical both from mechanical and financial standpoints.

### Old Method of Hand Ramming.

Before proceeding to a description of the ramming machine, which it is the more immediate purpose of this article to describe, it will be well to review briefly the general features of hand ramming. From two to eight men stand around the opening of the moulding box, which is anything up to 18 ft. in depth and extends through a platform. By means of correspondingly long rammers they ram the open annular chamber around the pattern with moulding sand, which is filled in by one or two more men. It is evident that this kind of work requires a considerable number of skilled labourers. Further, these operators must know how to work well together in order to produce clean finished moulds. Supposing there is only one amongst this set of men who does not possess the required skill, or does not do the work properly for any other reason, the moulds will turn out defective and produce unsaleable pipes, which constitutes a severe loss for the foundry.

Another difficulty experienced in iron foundries doing the ramming work by hand is to procure the skilled labourers required for this work. As the ramming by hand in dust-laden air, which cannot be avoided in pipe foundries, is very arduous and injurious to health, men can only be got for this work when they are paid a very high wage. In times and districts where working opportunities are always and everywhere available, it is often difficult to obtain pipe moulders even for the highest wages. Change amongst these men is, of course, constantly taking place, and they are absent owing to illness more frequently than other workmen.

From the foregoing it will be evident that the problem of making good moulds cheaply cannot be solved by means of the usual method of hand-ramming. The difficulties, however, are claimed to have been successfully overcome by the invention of Mr. Robert Ardelt, superintendent of one of the most important German foundries, whose ramming machine will now be described.

### New Method of Machine Ramming.

The machine rams the moulds exactly after the manner of hand-ramming. From four to sixteen rammers of small length (about 16 in. to 20 in.) are spring-mounted on a short tubular piece. By means of the resiliency of the rammers, it is possible to also ram the thicker socket, when casting pipes with socket downwards.

The ring with the rammers is carried by from two to eight rods being of the same length as the pipe to be made. These rods are engaged by a lifting gear

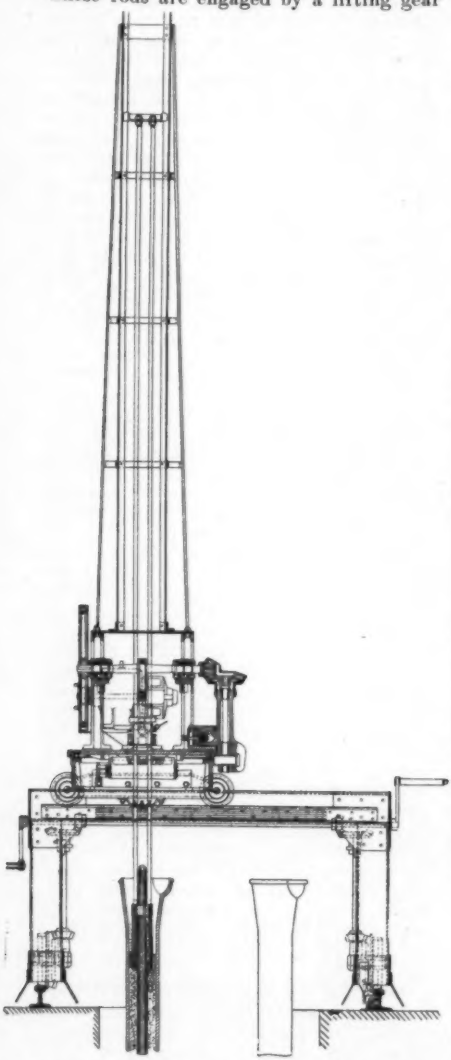


FIG. 2.—THE "ARDELT" PIPE MOULD RAMMING MACHINE; ARRANGEMENT OF PORTABLE TYPE.

and moved up and down. The latter is mounted on a turn plate, with which it rotates the rammers. The number of strokes is 120 to 160 per minute. As soon as a mould is rammed up, the rammer is lowered into the next empty box and is set into operation by its own weight and a brake mechanism. The machine is driven by a motor having a capacity of 12 to 5 h.p.

Attendance on the smaller type of the machine requires two men. One of them has to adjust the machine over the middle of the moulding box and stop and start it. The other is engaged in shovelling the moulding sand into the box. In the case of larger machines, two or three men must introduce the sand.

The machine is capable of making all kinds of pipes of from 1.2 to 60 in. inside. It rams not only socket and flanged pipes, but also soil pipes and economisers.

The makers state that existing installations can be readily made use of, and new moulding boxes, patterns, or the like are not required. The quality of the moulding sand used in ramming up the moulds by hand also remains the same. The capacity of the machine can be regulated to the amount of sand introduced, and, owing to the fact that the ramming rods can be tightened or loosened by means of a crank, the operator is able to ram the mould more or less firmly and compactly.

In pipe foundries having the moulding boxes arranged in a circle, the machine is mounted on turn-tables on a vertical rotary crane, and the moulding box passes under it. In other foundries having the boxes arranged in rows, the machine is mounted on a portable trestle crane frame and moved from box to box. The mechanism of the machine is not so complicated but that it can be readily understood by any intelligent labourer in a few hours. The following table shows the time required for the ramming up of the moulds, including introduction and removal of the pattern, blackening and finishing of the mould :—

| In. int. dia. | Ft. | In. long. | Lengths in 1 hour. |
|---|---|---|---|
| 1.6 | 10 | 0 | 27 |
| 2.0 | 10 | 0 | 27 |
| 2.4 | 10 | 0 | 27 |
| 2.8 | 11 | 6 | 23 |
| 3.2 | 11 | 6 | 23 |
| 3.6 | 11 | 6 | 21 |
| 4.0 | 11 | 6 | 21 |
| 5.0 | 13 | 6 | 20 |
| 6.0 | 13 | 6 | 20 |
| 7.0 | 13 | 6 | 18 |
| 8.0 | 13 | 6 | 18 |
| 9.0 | 13 | 6 | 18 |
| 10.0 | 13 | 6 | 16 |
| 11.0 | 13 | 6 | 16 |
| 12.0 | 13 | 6 | 14 |
| 14.0 to 16.0 | 13 | 6 | 14 |
| 18.0 to 20.0 | 13 | 6 | 14 |
| 22.0 to 24.0 | 13 | 6 | 10 |
| 26.0 to 30.0 | 13 | 6 | 8 |
| 32.0 to 40.0 | 13 | 6 | 5 |

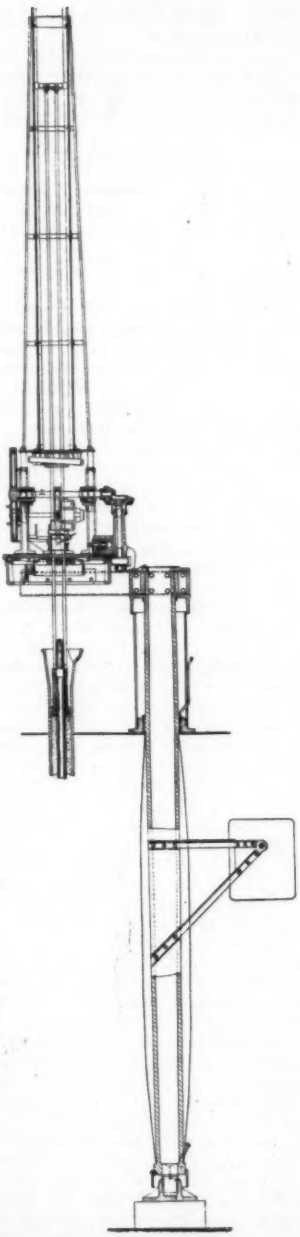


FIG. 3.—"ARDELT" PIPE MOULD RAMMING MACHINE; ARRANGEMENT OF STATIONARY TYPE.

The saving of wages realised by the installation of the machine is claimed to be as high as 33⅓ to 50 per cent. per ton, and the saving of iron from 1 to 15 per cent. In a modern foundry equipped with first-class machinery the economy will, of course, be much greater still.

We understand that during the last two years twenty of these ramming machines have been installed in Germany as well as in other foreign foundries.

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## MOULDING SAND.

By M. I. P.

SAND is an important item in the moulder's outfit, for with sand, a blacking bag, and a wooden cope box he can perform wonders in the floor when flasks are not available.

It is necessary that the moulder should know that sand possesses certain properties that render it peculiarly suitable for his purposes; that its main features are refractoriness, strength, and porosity; that refractoriness depends upon the amount of silica in the sand and the absence of certain common elements which impair the qualities of the sand by combining with the silica at high temperatures. A knowledge of silica alone as an element in the chemical table, its various modifications, and its relation to other elements and compounds cognate to the trade, would add an interest to work too often regarded as entirely lacking in technical interest.

### Sand Bonding.

The ideal moulding sand is that which contains the correct amount of silica to ensure general refractoriness and the clay or argillaceous matter in the minimum quantity consistent with the strength required. The sand when thoroughly mixed should have in substance a grain consisting of granules of pure sand or quartz of uniform size, but irregular shape. The size and shape of the grains regulate the porosity of the mould, which again is affected by the amount of ramming employed.

The correct adjustment of strength and porosity of sand is somewhat difficult, though many natural sands containing the requisite amount of bond and porosity are obtainable and give good results.

Strength, whether due to natural or added clay bond, does not always go hand in hand with other desirable properties. The question of perfect mixing turns upon the uniform distribution of bond within the mass, which can obviously never be

perfect under economical conditions of mixing, but an insight into the general requirements must result in improvements on the existing rough and ready methods.

In green sand moulding the minimum quantity of bond or clay only is permissible as the maximum permeability is required. It should not appear strange that greater permeability or openness is wanted in a green mould taking the same iron and consequently containing the same amount of "gases" as the iron used in a dry mould; obviously, if the same iron is used the same quantity of gas is contained therein, but it must be remembered that the rate of rejection of occluded gas varies with the rate of cooling. Less time being generally allowed for cooling in the case of green moulds, less time is allowed for the gas to get away. Moreover, the bulk of the gas seen issuing from the vents of a mould come from the interior and the body of the mould itself, and not from the iron.

This advocacy of a minimum bond will be, undoubtedly, taken to be a dangerous policy by many moulders who work "safe," but it is here asserted that "for all castings of any size or design the best mould is that which at the time of casting most nearly approaches its limit of strength or its point of collapse."

Of course, open sand alone will not produce a perfectly collapsible mould, many other expedients being known to the moulder capable of producing a "rotten" mould, which methods need not be discussed here; sufficient to say, that strong, over-bonded sand is one of the chief factors in the case.

Another aspect of bonding is shown in the case of artificial bonds of the carbonaceous class, such as molasses, flour, beer, dextrin, etc., all of which bind, but unlike clay bonds, assist rather than prevent porosity provided that the mould is properly dried, and excess avoided.

It is necessary that in drying these moulds a sufficient temperature be reached to char the carbonaceous substance added in solution, or at least, partially.

The action of heat upon these hydrocarbons generally is first, to evaporate the water of solution, with the production of a tarry or sticky body containing volatile matter, which, when expelled, leaves a carbonaceous residue resembling coke, very finely distributed through the mass and binding very much as coke particles cohere on the expulsion of tarry matters in the coke oven. An unduly high temperature in drying, burns out these carbonaceous particles from the sand and gives what is known to the moulder as a burnt mould or core for some distance below the surface.

A moulder should remember that in high-class dry sand moulding, the minimum workable bond in the sand when dried is what should be attempted.

### Purity in Sands.

Large founders possessing laboratories very wisely subject to analysis, from time to time, the raw materials going into the sand mixing room. It pays to do so when any new brand of sand or clay is introduced.

The evil effects of lime when present in refractory materials is well known, and it is very apt to occur in and near their natural deposits. The form in which it chiefly occurs is that of limestone.

A firebrick manufacturer would get a shock if he found he was using a clay containing 2 per cent. of lime; yet many of our English clays similar to those used for clay work, etc., in foundries, contain upwards of 20 per cent. of limestone. This sounds startling, but is a fact; and where sand and clay is brought into the foundry without discrimination becomes a serious one.

In no other department is this question of quality so important as it is in the steel foundry, where facings have to be specially ground and mixed, and the same scope for "natural sand" selection is not offered. The danger in steel casting is heightened by the extremely searching nature of the steel due to the great heat of casting. One wide-awake foreman, known to the writer, suspecting his "silica" sand of containing carbonates, threw a truck load of it into a steel furnace which had been used for melting, and was cooling down; the heat was sufficient to thoroughly calcine any carbonates present and make them soluble. The whole lot of sand was afterwards soaked in water and the water which was practically neutral before was found to be alkaline afterwards. Simply explained, the test is this:—Normal anhydrous carbonates are not so soluble in water as their oxides. Calcium carbonate, of which limestone is a variety, is turned into lime or calcium oxide when it is highly heated, and the lime being much more soluble in water, is quickly detected by a simple test.

The danger is even greater when the impurities are in the refractory washer used in steel work, and of which so much secrecy is maintained amongst founders. Some years ago the writer tested a sample of graphite, or plumbago, and found to his astonishment it contained no less than

50 per cent. of siliceous matter and other bodies not combustible in oxygen; this ash contained alkaline bodies.

The effect of alkaline and other fluxable bodies in the facings is to give rough and dirty-looking castings to which the sand adheres, thus increasing the cost of cleaning and giving an inferior casting. The chemical effect is one of incipient slagging or fluxing, which on repeating grows worse until the sand becomes useless.

### Testing of Sand.

No well-made mould of any considerable design, either dry or green, is rammed uniformly throughout; the merest tyro in the foundry knows that some parts of the mould are rammed softer than others. This, to be effectual, demands a sand of uniform texture to be used for the entire mould, for obviously, over-bonded sand or one that will dry hard and close-grained, used at the point where soft ramming is necessary, is equivalent to hard ramming at that point. On the other hand, a sand of minimum bond used for the entire mould, and extra ramming and ironing given where strength is needed, is obviously the thing to be aimed at, as the construction of the mould as to strength is then at the command of the moulder.

A moulder when mixing his sand is seen to pick up a handful of his mixture, squeeze it and throw it down again, often without looking at it. Or he may close his fingers on it, knock his knuckles on his knee, thus partly ramming the sand into a cake; then, by balancing the cake between his fingers and noting the readiness or otherwise with which it breaks, he decides whether or not his sand will do. In other words, he has tested his sand for strength.

This is another instance of "rule-of-thumb," or the personal element in the work, as scarcely any two men, if examined, would exactly agree in their conclusions; yet both will make good castings.

It must be perfectly clear to any moulder or manager, who has seen anything of the testing of materials, other than metals, by physical methods, that just as the only reliable tests made to determine the qualities of sand and clays, etc., with cement as a bond, or even cement itself, are those in which the personal element is almost entirely absent, so it must be in the case of foundry sands.

Any man ramming test bars from the same box or mould, with the same sample of sand, will obtain varying results, while, on the other hand, mechanical ramming with haphazard methods of mixing must also be unsatisfactory.

It is not too much to hope that we may yet reach a stage in which the standardising and standard testing of foundry sands is as easily possible as that of cements and cement mixtures.

We have described a moulding sand as consisting, in mass, of silica grains cemented together with argillaceous matter or clay in small quantities, this must be so, whether the sand is natural or made up. This description, of course, includes nothing of the substances required to open it out sufficient for use, but shows to a degree the remarkable resemblance between a moulding sand and a cement mixture as made up experimentally for the testing of cements in the laboratory, which consists of granular particles of pure "Leighton Buzzard" sand, much larger than the moulder's grains, accurately weighed out and mixed with a weighed quantity of cement. These two are mechanically mixed together with a definite quantity of water run from a graduated burette (automatic), the temperature of which water is taken. from time to time.

At this stage, the mixture resembles the moulder's "mix." It is then transferred to small iron test moulds resembling a core box and rammed in a machine constructed on the principle of the old-fashioned helve, but quite modern itself.

By this process the core is given a definite number of blows of definite strength, which number is automatically checked to avoid mistake. The core is then treated by standard methods as to drying, time, etc., and broken in a delicately poised test machine. The power required to break the "test bar," or core of sand and cement, is carefully noted, and deductions are arrived at as to its suitability for various purposes.

The conditions are analogous throughout, and will suggest possibilities to the foundryman as to what may be done by the application of scientific methods to the already existing methods of sand testing. Indeed, if the idea of standardising of foundry sands is ever to materialise, something in this shape will have to be adopted.

The writer has found that cores made with the American hammer core machine from carefully made mixtures, give very uniform results as to "over-hang." The core is, of course, not rammed, but pressed by rotary or screw motion.

## CAST-IRON PIPE STANDARD SPECIFICATIONS.

THE BRITISH ENGINEERING STANDARDS COMMITTEE have issued the two following reports dealing with the important subject of the standard dimensions, weights, etc., of cast-iron pipes :—

Report No. 40 for Cast-iron Spigot and Socket Low-pressure Heating Pipes.

Report No. 41 for Cast-iron Spigot and Socket Flue or Smoke Pipes.

A point of special interest in both specifications is the stipulation that no

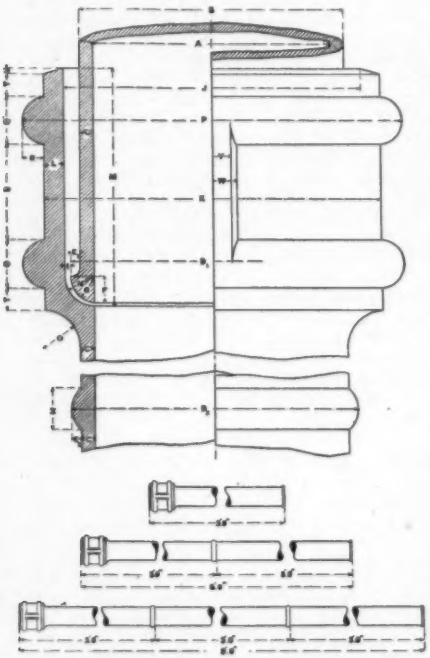


FIG. 1.—BRITISH STANDARD LOW-PRESSURE HEATING PIPES; KEY PLAN.

pipe shall have an internal diameter or bore of less than nominal dimensions, that is to say, the purchaser of a 6-in. standard pipe shall obtain a pipe of 6 in. in internal diameter instead of one of 5⅞ in., or even less, as is at present very often the case. The specifications also require the pipes to be marked with distinctive class letters to show the purposes for which they were made, and also with the manufacturer's trade mark or initials for the purpose of identification. Standard dimensions and designs for the soot doors of the various sizes of pipe are given in the specification for flue or smoke pipes, and both specifications are complete with tables of dimensions of the standard pipes and fittings.

Abstracts of the reports are appended :

### Cast-iron Spigot and Socket Low-pressure Heating Pipes.

In drawing up the weights of pipes and depths of sockets the Sub-Committee have

*Dimensions and Weights of British Standard Low-pressure Heating Pipes, for Working Pressures up to* 100 *Ft. Head.*

| | | DIMENSIONS OF PIPES. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| PIPE. | A | 2⅜ | 3½ | 4⅝ | 5⅞ | 6⅞ | 7⅝ | 8⅜ | 9⅝ |
| | B | 2⅜ | 3½ | 4⅝ | 5⅞ | 6⅞ | 7⅝ | 8⅜ | 9⅝ |
| | C | 5/16 | 5/16 | 11/32 | 5/16 | 5/16 | 11/32 | 3/8 | 11/32 |
| | D, D₁ | 2⅜ | 3⅜ | 4⅝ | 5½ | 7 | 8⅛ | 9⅞ | 10 5/16 |
| | E, E₁ | ½ | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | ½ |
| | F | 5/16 | ⅜ | 5/16 | ½ | ½ | 5/16 | ½ | 11/32 |
| | G | 5/16 | ½ | 11/32 | 11/32 | ½ | 5/16 | 11/32 | 11/32 |
| | H | 5/16 | ½ | 11/32 | ½ | ½ | ½ | ½ | ½ |
| Clearance | I | ½ | 5/16 | 5/16 | ½ | ½ | ½ | 5/16 | 5/16 |
| Caulking Space | E, + I | ½ | ½ | 11/32 | 5/16 | 5/16 | 11/32 | ½ | 11/32 |
| SOCKET. | J | 2½ | 3 11/32 | 5 | 6 5/16 | 7½ | 8⅜ | 9½ | 10½ |
| | K | 3 5/16 | 4 5/16 | 5 11/32 | 6 11/32 | 6 5/16 | 9½ | 10 5/16 | 11½ |
| | L | 5/16 | 5/16 | 11/32 | ½ | 11/32 | 5/16 | 11/32 | ½ |
| | M | 3 | 3½ | 4 | 4 | 4½ | 4½ | 5 | 5 |
| | N | 5/16 | 11/32 | ½ | 11/32 | ½ | 11/32 | ½ | 11/32 |
| | O | 5/16 | 5/16 | ½ | 11/32 | ½ | ½ | ½ | 11/32 |
| | P | 3 11/32 | 5½ | 6 11/32 | 7 11/32 | 8 11/32 | 10½ | 11 5/16 | 12½ |
| | Q | 5/16 | 11/32 | 11/32 | ½ | 1 | 1 | 1½ | 1½ |
| | R | ½ | 11/32 | ½ | ½ | 5/16 | 5/16 | ½ | ½ |
| | S | 1½ | 1 5/16 | 1 11/32 | 1 11/32 | 1 11/32 | 1½ | 1 11/32 | 1 11/32 |
| | T | ½ | ½ | ½ | ½ | ½ | ½ | ½ | 5/16 |
| | U | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | ½ | ½ |
| | V | 5/16 | 11/32 | ½ | 11/32 | ½ | ½ | ½ | ½ |
| | W | 5/16 | 11/32 | 11/32 | ½ | 1 | 1 | 1½ | 1½ |

| MINIMUM WEIGHTS OF PIPES. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 3 | 15 | 24 | 32 | 50 | 67 | 86 | 108 | 130 |
| 6 | 27 | 45 | 61 | 94 | 125 | 160 | 201 | 243 |
| 9 | — | 66 | 90 | 138 | 183 | 234 | 294 | 356 |

endeavoured, as far as possible, to work between the heavy pipes and deep sockets specified by some public bodies and the light pipes and short sockets now in use in many districts. The Sub-Committee are of opinion that with the depths of sockets and the weights recommended the standard pipes will not be too heavy to be used for ordinary contracts, and at

the same time will be thoroughly sound and reliable.

The Sub-Committee are unanimously of opinion that the internal diameters of all pipes and fittings should be the same size as the nominal or commercial sizes. The internal diameters of pipes of the same nominal size which are being used at the present time vary in some cases considerably, and the Sub-Committee

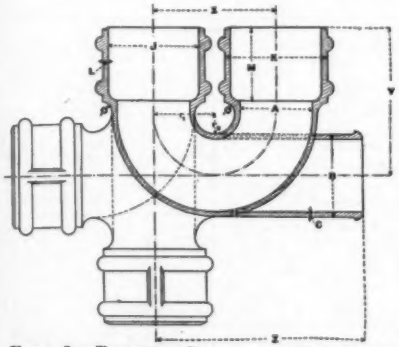


FIG. 2.—BRITISH STANDARD HOT-WATER FITTINGS FOR WORKING PRESSURES UP TO 100 FT. HEAD.

DIMENSIONS OF FITTINGS.

| INTERNAL DIAMETER | A | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Approximate External Diameter of Pipe | B | 2⅝ | 3 1/16 | 4 1/16 | 5 1/16 | 6⅛ | 7 1/16 | 8⅛ | 9 1/16 |
| Approximate Projections of Pipe | C | 1/16 | 1/16 | ⅛ | 1/16 | 1/16 | ⅛ | ¼ | ⅛ |
| Internal Diameter of Socket | J | 2⅛ | 3 1/16 | 5 | 6 1/16 | 7⅛ | 8⅛ | 9⅛ | 10⅛ |
| External Diameter of Socket | K | 3 1/16 | 4 1/16 | 5 1/16 | 6 1/16 | 8 1/16 | 9⅛ | 10 1/16 | 11⅛ |
| Thickness of Socket | L | 1/16 | 1/16 | ⅛ | ⅛ | ⅛ | 1/16 | ⅛ | ⅛ |
| Internal Depth of Socket | M | 3 | 3½ | 4 | 4 | 4½ | 4½ | 5 | 5 |
| External Radius of Socket | O | 1/16 | 1/16 | ⅛ | ⅛ | ¼ | ¼ | ¼ | ⅛ |
| Centres of Sockets | X | 4½ | 5½ | 6½ | 8 | 9½ | 10½ | 12 | 13½ |
| Centres to Centres Line of Spigot | Y | 5½ | 6 1/16 | 8½ | 8½ | 9½ | 10½ | 11 1/16 | 12½ |
| Length of Spigot | Z | 9 | 10 | 11½ | 13 | 14½ | 16 | 17½ | 19 |
| Radius of Centre Line of Spigot | $r_1$ | 2 1/16 | 2⅛ | 3½ | 4 | 4½ | 5½ | 6 | 6½ |
| Internal Radius of Bend | $r_2$ | ½ | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1⅛ | 1⅛ | 1⅛ |

Sockets of Fittings to be the same as for Straight Pipes of corresponding bore.

consider such variation, both from technical and commercial points of view, to be extremely undesirable.

With regard to the standard lengths of heating pipes recommended, the attention of the Sub-Committee has been drawn to the question of making the standard length the length as laid. While unanimously in agreement with the principle, they desire to point out that it is the general custom in the case of heating pipes to make the nominal length include the socket. In view of this fact they feel that any recommendation with regard to a change in this practice would greatly retard, if it did not entirely prevent, the adoption of the standards.

The Sub-Committee further desire to point out that as these pipes are always sold by length, it has not been deemed necessary to specify a maximum limit of weight, a minimum limit only being required.

*Standard Specification.*

(1) The pipes and fittings shall conform in every respect to this specification, and to the schedule and drawings hereunto annexed. The astragals and beads shall be placed as shown on the drawings, and the sockets of all fittings shall conform to the dimensions shown in the table for the straight pipes. The internal diameter or bore shall in no case be less than the nominal diameter. The fittings shall be of the same thickness and relative weights as the straight pipes.

(2) The pipes and fittings shall be made from remelted iron, and the metal shall be dark grey on fracture.

(3) The pipes may be cast horizontally.

(4) The pipes and fittings shall be true and cylindrical, their inner and outer surfaces being as nearly as may be concentric. They shall be in all respects sound and good castings, free from laps or other imperfections, shall be neatly dressed and carefully fettled.

(5) The straight pipes shall be made in the following lengths, which are inclusive of the depth of the socket:—2 in. internal diameter, 3 ft. and 6 ft. lengths; 3 in. internal diameter and over, 3 ft., 6 ft., and 9 ft. lengths. The pipes dealt with in this specification shall be of not less weight than that specified in the Schedule. The weight shall be worked to in preference to the external diameter, which is given approximately to the nearest $\frac{1}{32}$ in.

(6) Every pipe and fitting shall have cast upon it in a legible manner a figure indicating the internal diameter, and also class letters "S.H." (Standard Heating) to indicate the purpose for which the pipe or fitting is made, and that it purports to have been manufactured in accordance with the British Standard Specification. In addition to the class letters, each pipe or fitting shall bear the initials or trade mark of the manufacturer and the year of manufacture, *e.g.*, 4 S.H. X & Co., '08.

(7) All sizes of low-pressure heating pipes and fittings shall be tested by an internal hydraulic pressure of 100 lbs. per square inch, and they shall withstand such pressure without showing any leakage, sweating, or defect of any kind. The pressure shall be maintained for at least two minutes. Care shall be taken that all air is extracted before the test is commenced. While under this pressure each pipe and fitting shall be struck all over with a hand hammer weighing $\frac{1}{4}$ lb.

(8) The representative of the engineer

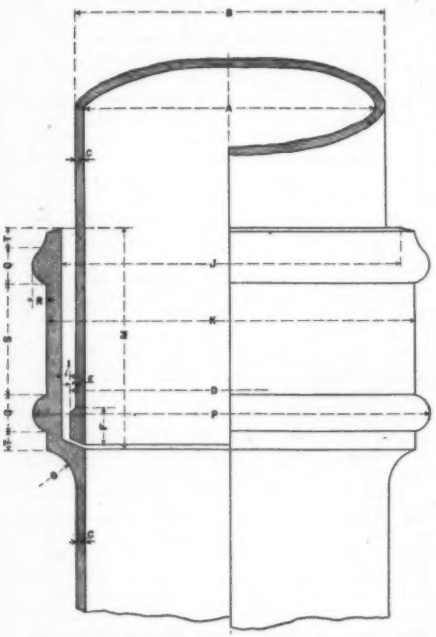


FIG. 3.—BRITISH STANDARD FLUE OR SMOKE PIPES; KEY PLAN.

(or of the architect) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material, finished pipe or fitting that does not conform to the terms of this specification.

(9) The manufacturer shall, at his own cost, supply labour and appliances for such testing as may be carried out on his premises.

The Schedule to the specification includes a series of sectional diagrams, drawn to full size, indicating the socket designs and dimensions for low-pressure heating pipes from 2 in. to 9 in. internal diameter.

### Cast-iron Spigot or Socket Flue or Smoke Pipes.

In presenting the specification and sections of cast-iron spigot and socket flue or smoke pipes, the Sub-Committee lay down the same rules as regards internal

*Dimensions and Weights of British Standard Flue or Smoke Pipes.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PIPE. | DIMENSIONS OF PIPES. | | | | | | | | | | |
| | INTERNAL DIAMETER | A | in. 4 | in. 4½ | in. 5 | in. 6 | in. 7 | in. 8 | in. 9 | in. 10 | in. 12 |
| | Approximate External Diameter | B | 4⅝ | 4⅞ | 5⅛ | 6 5/16 | 7⅜ | 8 5/16 | 9⅜ | 10 5/16 | 12⅜ |
| | Approximate Thickness | C | ½ | ½ | ½ | 5/16 | 5/16 | 5/16 | ½ | 5/16 | 5/16 |
| | Diameter of Spigot Band | D | 4⅞ | 5⅛ | 5⅜ | 6 5/16 | 7⅜ | 8 5/16 | 9⅜ | 10⅜ | 12⅜ |
| | Projection of Spigot Band | E | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | ½ | ½ | ½ |
| | Width of Spigot Band | F | ½ | 5/16 | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| | Chamfer | I | ½ | ½ | ½ | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 |
| | Caulking Space | E+I | 5/16 | 5/16 | 5/16 | 5/16 | 5/16 | ½ | 5/16 | ⅝ | ⅝ |
| SOCKET. | Internal Diameter | J | 4⅝ | 4⅞ | 5⅛ | 6⅜ | 7⅛ | 8⅛ | 10⅛ | 11⅛ | 13 5/16 |
| | External Diameter | K | 5 | 5⅜ | 6 | 7 5/16 | 8 5/16 | 9⅜ | 10⅜ | 11⅝ | 14 5/16 |
| | Thickness | L | 5/16 | 5/16 | 5/16 | 5/16 | ½ | 5/16 | 5/16 | ⅝ | ½ |
| | Internal Depth | M | 3 | 3 | 3½ | 3½ | 3½ | 4 | 4 | 4½ | 4½ |
| | External Radius | O | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| | Diameter of Bead | P | 5⅛ | 5⅝ | 6⅛ | 7⅛ | 8⅛ | 10 5/16 | 11⅛ | 12 5/16 | 14⅛ |
| | Width of Bead | Q | ½ | ⅝ | 5/16 | ⅝ | ½ | ⅝ | ⅝ | ⅝ | ½ |
| | Projection of Bead | R | 5/16 | 5/16 | 5/16 | 5/16 | ½ | 5/16 | 5/16 | ⅝ | ½ |
| | Distance between Beads | S | 1⅛ | 1 5/16 | 1⅛ | 1⅛ | 1⅛ | 1 5/16 | 2 | 2 5/16 | 2⅛ |
| | Distance of Bead from Edge | T | ½ | ½ | ½ | ½ | ½ | 5/16 | 5/16 | 5/16 | 5/16 |
| | Angle of Bottom of Socket | | 22½° | 22½° | 22½° | 22½° | 22½° | 22½° | 22½° | 22½° | 22½° |
| | MINIMUM WEIGHTS OF PIPES. | | | | | | | | | | |
| | OVERALL LENGTH. Feet. | | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| | 3 | | 18 | 20 | 23 | 34 | 45½ | 59 | 76 | 94 | 138 |
| | 6 | | 33 | 36 | 46 | 63 | 86 | 112 | 144 | 176 | 265 |

diameter and lengths as in the case of low-pressure heating pipes.

*Standard Specification.*

The specification is identical in every respect with that for low-pressure heating pipes, except that all straight pipes are to be made in 3 ft. and 6 ft. lengths, which are inclusive of the depth of the socket.

In this case also the Schedule includes full size sections of joints, in pipes from 4-in. to 12-in. internal diameter.

### Personnel of Sectional Committee.

The following are the members of the Sectional Committee on Cast-iron Pipes

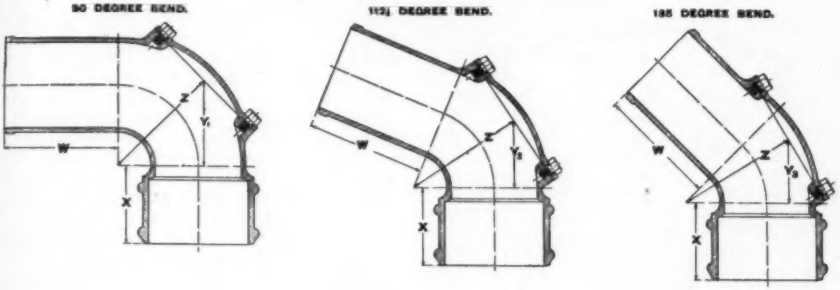
and of the Sub-Committee on Cast-iron Pipes for Heating, Ventilating, and House Drainage, which was entrusted with the drafting of the standard specification and sections of cast-iron spigot and socket flue or smoke pipes :—

*Sectional Committee on Cast-iron Pipes.*

Mr. Charles Hawksley, Chairman; Messrs. W. E. Phelps, representing the India Office; Osbert Chadwick, C.M.G., representing the Crown Agents for the Colonies; Martin Roberts, representing the General Post Office; C. S. Carpenter and Charles Hunt, nominated by the Institution of Gas Engineers; F. Griffiths and W. Watts, nominated by the Incorporated Association of Municipal and County Engineers; F. Bancroft, W. Matthews, and P. H. Palmer, nominated by the British Association of Water Works Engineers; Louis F. Pearson, nominated by the Institution of Heating and Ventilating Engineers; C. H. Bowser, F. Chambers, J. Cochrane and H. Westlake, nominated by the Cast-iron Pipe Founders' Association of Great Britain; William B. Bryan, Colin Docwra, E. B. Ellington, *Basil P. Ellis, W. E. Gray, George H. Hill, Ernest Mansergh, Henry Roff, and G. Watson, Leslie S. Robertson (secretary), and Charles Dresser (assistant secretary).

* Deceased October, 1907.

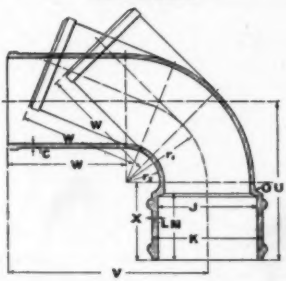
KEY PLANS OF BENDS WITH SOOT DOORS.




DIMENSIONS OF BENDS.

| INTERNAL DIAMETER | | A | 4 ins. | 4½ ins. | 5 ins. | 6 ins. | 7 ins. | 8 ins. | 9 ins. | 10 ins. | 12 ins. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Approximate External Diameter of Pipe | | B | 4¼ | 4¾ | 5¼ | 6 5/16 | 7⅜ | 8 7/16 | 9½ | 10 9/16 | 12⅝ |
| Approximate Thickness of Pipe | | C | ⅛ | ⅛ | ⅛ | 3/32 | 5/64 | 7/64 | ⅛ | 9/64 | 5/32 |
| Internal Diameter of Socket | | J | 4⅛ | 5⅛ | 5⅛ | 6⅛ | 7 1/16 | 8 1/16 | 10⅛ | 11⅛ | 13 1/16 |
| External Diameter of Socket | | K | 5 | 5½ | 6 | 7 5/16 | 8 5/16 | 9½ | 10¾ | 11⅞ | 14 1/16 |
| Thickness of Socket | | L | 5/16 | 5/16 | 5/16 | 7/32 | ¼ | 5/32 | 5/16 | 11/32 | ⅜ |
| Internal Depth of Socket | | M | 3 | 3 | 3½ | 3½ | 3½ | 4 | 4 | 4½ | 4½ |
| External Radius of Socket | | O | ½ | ½ | ½ | ⅝ | ⅝ | ¾ | ¾ | ⅞ | ⅞ |
| Length of Socket Branch | | U | 7½ | 7⅝ | 7⅞ | 8 3/16 | 9 5/16 | 10 7/16 | 11½ | 12 9/16 | 13 11/16 |
| Length of Spigot Branch | | V | 9 | 9½ | 10 | 11 | 12 | 13 | 14 | 15 | 17 |
| Length of Spigot | | W | 5⅜ | 5⅝ | 5⅞ | 6 7/16 | 6 15/16 | 6 13/16 | 7½ | 7 13/16 | 8 7/16 |
| Length of Socket | | X | 3½ | 3½ | 3½ | 4½ | 4½ | 4½ | 4½ | 5½ | 5½ |
| Centre of Soot Door Opening | 90° Bend | Y1 | 3⅜ | 4½ | 4½ | 5⅜ | 6½ | 7½ | 7⅞ | 8⅜ | 10½ |
| | 112½° Bend | Y2 | 3 | 3⅜ | 3½ | 4½ | 4⅞ | 5⅜ | 6½ | 7 | 8 |
| | 135° Bend | Y3 | 2⅞ | 3 | 3⅛ | 3⅞ | 4⅛ | 4⅞ | 5⅛ | 5⅞ | 6⅜ |
| | All Bends | Z | 5½ | 6 | 6⅜ | 7⅜ | 8⅜ | 10 | 11½ | 12⅜ | 14½ |
| Radius of Centre Line of Bend | | r1 | 3⅜ | 3⅞ | 4½ | 4 11/16 | 5 7/16 | 6 3/32 | 6¾ | 7 13/32 | 8 7/16 |
| Internal Radius of Bend | | r2 | 1½ | 1⅞ | 1½ | 1⅞ | 1⅞ | 1⅞ | 2 | 2⅛ | 2⅛ |

KEY PLAN OF BENDS WITHOUT SOOT DOORS.




Sockets of Bends to be the same as for Straight Pipes of corresponding bore.

FIG. 4.—BRITISH STANDARD FLUE OR SMOKE BENDS. 90, 112½, AND 135 DEGREES.

*Sub-Committee on Cast-iron Pipes for Heating, Ventilating, and House Drainage.*

Mr. Louis F. Pearson, Chairman; Messrs. F. T. Reade, representing the Royal Institute of British Architects; F. S. Capon and J. E. Worth, representing the London County Council; Edwin T. Hall, representing the Royal Sanitary Institute; John Cameron, Cameron & Roberton, Limited; C. W. Dawson, Newton, Chambers & Company, Limited; W. Jones, Jones & Attwood; Charles Mason, Foster & Pearson, Limited; J. Nelson Russell, Rosser & Russell, Limited; A. K. Steven, McDowall, Steven & Company, Limited, and W. McLauchlan, Walter Macfarlane & Company.

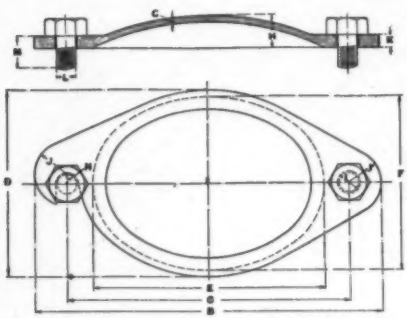


FIG. 5.—BRITISH STANDARD SOOT DOOR.

DIMENSIONS OF SOOT DOOR.

| INTERNAL DIAMETER OF PIPE | | 4 in. | 4½ in. | 5 in. | 6 in. | 7 in. | 8 in. | 9 in. | 10 in. | 12 in. |
|---|---|---|---|---|---|---|---|---|---|---|
| Length over Lugs | B | 6½ | 6½ | 7½ | 7½ | 9 | 9 | 10 | 10 | 11 |
| Thickness of Lid | C | ¼ | ¼ | ¼ | ⅜ | ⅜ | ⅜ | ¼ | ⅜ | ⅜ |
| Width of Lid | D | 3½ | 3½ | 4½ | 4 1/16 | 5½ | 5 1/16 | 6½ | 6 1/16 | 7 |
| Length of Opening | E | 4½ | 4½ | 5½ | 5½ | 6½ | 6½ | 7½ | 7½ | 8½ |
| Width of Opening | F | 3½ | 3½ | 4½ | 4½ | 4½ | 4½ | 5½ | 5½ | 6½ |
| Centres of Holes | G | 5½ | 5½ | 6½ | 6½ | 7½ | 7½ | 8½ | 8½ | 9½ |
| Projection of Lid | H | ½ | ½ | ½ | ½ | ½ | ½ | ½ | 1 | 1 |
| Diameter of Holes | I | 1/16 | 1/16 | 1/16 | 1/16 | ¼ | ¼ | ¼ | 1/16 | 1/16 |
| Radius of Lugs | J | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ |
| Thickness of Lugs | K | ½ | ½ | ½ | ½ | 1/16 | 1/16 | ⅛ | ⅛ | ⅛ |
| Diameter of Set Fins | L | ⅛ | ⅛ | ⅛ | ⅛ | 1/16 | 1/16 | 1/16 | ½ | ½ |
| Length of Set Fins | M | ½ | ½ | ½ | ½ | ½ | ½ | 1 1/16 | ½ | ½ |
| | N | 1/16 | 1/16 | 1/16 | 1/16 | 1/32 | 1/32 | 1/32 | ½ | ½ |

—o—

MR. F. D. PHILLIPS, 2, Dock Chambers, Cardiff, has been appointed the agent for South Wales, Monmouthshire, and Gloucester of the Midland Coal, Coke, and Iron Company, Limited, of Apedale, Newcastle, Staffs., for foundry pig-iron.

## BRITANNIA-METAL AND HOW IT IS MADE.

ALTHOUGH it is a popular belief that britannia-metal has practically passed out of existence, as a matter of fact more is now used than ever before. This apparent paradox is explained by the fact that in former times britannia-metal was used without plating, and was known and sold as such; while to-day it is usually silver-plated.

Britannia-metal is an outgrowth of pewter. Pewter, so extensively used in former times, contained a large proportion of lead. The poisonous nature of lead brought about the desire to eliminate it. Britannia-metal, which contains no lead, was, therefore, evolved.

According to the best authorities, britannia-metal was first made by Messrs. Hancock & Jessop, of Sheffield, England, in the year 1770.

The advantage of britannia-metal lies in its non-corrosive properties. Tin is the principal constituent, and it is the most inert of the common metals. The small amounts of antimony and copper that are added to harden it do not affect its non-corrosive properties to any extent.

Although there is no uniform formula for britannia-metal, and it varies with the different makers, the difference between them is very slight. They all consist of tin, antimony and copper. The antimony and copper are added to the tin to harden it, as pure tin is too soft to be of service, and although it can be rolled and cast with ease, articles made of it will not hold their shape. The desired quality in britannia-metal is that it should be of sufficient hardness to hold its shape, and yet not be refractory in rolling or spinning.

One of the largest manufacturers of plated hollow-ware in the United States uses the following britannia-metal mixture :—

| | | |
|---|---|---|
| Tin ... ... | 150 lbs. | = 92.0 per cent. |
| Antimony... | 10 lbs. | = 6.2 per cent. |
| Copper ... | 3 lbs. | = 1.8 per cent. |

The preceding mixture is used for both rolling into sheet to be used for spinning or stamping, and for casting handles, ornaments, etc., in metal moulds.

Another large maker employs the following proportions of metals for making his goods : —

| | | |
|---|---|---|
| Tin ... ... | 140 lbs. | = 92.2 per cent. |
| Antimony... | 9 lbs. | = 5.9 per cent. |
| Copper ... | 3 lbs. | = 1.9 per cent. |

One of the smaller concerns, but makers of good goods, uses the following mixture :—

| | | |
|---|---|---|
| Tin ... | ... | 210 lbs. = 92.8 per cent. |
| Antimony... | | 12 lbs. = 5.4 per cent. |
| Copper ... | | 4 lbs. = 1.8 per cent. |

In making britannia-metal it is unwise to use cheap metals. Pure Straits tin, the best antimony, and a highly refined copper should be used. The best and usual method of making the mixture is first to make a "hardening" of the tin and copper which can be melted with the tin and antimony. The melting point of copper is so high that it cannot be melted in the iron kettle used for the tin. A plumbago crucible, therefore, is necessary.

To make the "hardening" equal parts of tin and copper are melted together and poured into small bars, so that they may be easily broken. This mixture will readily melt with the tin. To make the britannia-metal mixture, twice the amount of hardening is taken that there is copper. At the same time half the weight of the hardening must be deducted from the tin. In other words, if a britannia-metal mixture consisting of the following proportions is to be used :—

| | | |
|---|---|---|
| Tin ... | ... | 150 lbs. |
| Antimony | ... | 10 lbs. |
| Copper ... | ... | 3 lbs. |

Then to make it by the use of the "hardening" the change would be made to the following proportions :—

| | | |
|---|---|---|
| Tin ... | ... | 147 lbs. |
| Antimony | ... | 10 lbs. |
| Hardening | ... | 6 lbs. |

The "hardening" may be made in quantities so that it will be unnecessary to make a copper melt every time a bath of britannia-metal is mixed.

In making the britannia-metal, the antimony and hardening are placed in the bottom of the kettle and the tin on top. When the whole is melted, it is thoroughly stirred, and scrap added to cool it. The cooling is necessary for the reason that in order to melt the hardening and antimony, it is necessary to heat the metal hotter than the temperature used for casting it. In fact, the pouring temperature should be as low as possible, or the metal will crack in rolling.

Harder or softer britannia-metal mixtures may be made by increasing or decreasing the quantities of tin and copper. Too great an excess of copper will render the metal too hard to roll, and increase its melting point so that it is not easily cast. For both casting in metal moulds and for rolling into sheet to be afterwards spun or stamped the preceding mixtures will be found satisfactory, as they are in daily use, and are the result of many years' experience on the part of the leading makers of hollow-ware.—"BRASS WORLD."

## CORRESPONDENCE.

### Technical Schools for the Foundry.

*To the Editor of the* FOUNDRY TRADE JOURNAL.

SIR,—I should be glad if any of your readers could tell me of any technical or other school, where practical founding is taught, such as we find in some American cities. I think this is an important matter for the future of the foundry trade in this country, but as yet, little attention to this matter has been paid beyond what, perhaps, the British Foundrymen's Association has been doing. I understand one or two schools, or universities have lately adopted the teaching of practical founding. If this letter should come under their notice, they might kindly give a general idea of their system of teaching foundry work. In connection with the Heriot Watt College, Edinburgh, there are the iron shop, the smith shop, and pattern shop, etc., but no mention is made of a foundry. That Edinburgh has not seen fit to provide a foundry—an indispensable adjunct in the training of pattern-makers, is a mistake which time will doubtless rectify—at least, it is to be hoped so; otherwise the labour of the propagandists is lost. To teach pattern-making, or the fundamentals of workshop practice, without the positive application of the art to production, is neither more nor less than waste of time.

It must never be forgotten that the theory of pattern-making is got either directly or indirectly from the foundry, and the young man, or apprentice pattern-maker, who is isolated from the foundry, is badly handicapped with his *confréres* who have been trained where pattern shop and foundry were associated. As technical schools are not built for profit-making, but for the training of our young men to attain to higher distinction in the work of their choice, it follows that equipment should be complete if technical training is to mean more than an ornament in one's profession or trade. But to return to my original enquiry, if any of your readers can give me information on technical schools for the foundry, their situation, equipment, and curriculum, doubtless others will also feel obliged.

Yours, etc.,

"W. R."

SIR,—I have been successful in persuading our local Literary Committee (Darlington Education Committee—Technical College) to purchase T. D. West's books, "American Foundry Practice,"

and "The Moulders' Text Book," and can substantiate your remarks as to their practical value to the founder.

I am sending you a copy of our prospectus, that you may see what the Committee purpose doing if the workers will only evince sufficient interest in their own trade. The foundry-work class did not run after Christmas last session, owing to apathy on the part of those who might have greatly benefitted, and this session's prospects for the continuance of a foundry-class are not very bright. We have one hour of theory and one and-a-half hours' of practical instruction every Thursday night, provided the attendance is sufficient. We purpose doing practical work in all its branches, green sand, dry sand, loam work, and core-making, so the class can be made very interesting.

Yours, etc.

"R. E. C. T."

[The prospectus of the Darlington Technical College is dealt with elsewhere in our columns. *The Editor.*]

### Propeller Moulds.

SIR,—I have read with interest the article on "Propeller Moulds," by William Ashcroft, also "R.'s" better method, for covering, and am surprised at Mr. Ashcroft's letter in August issue. I have worked with both methods, and consider they are about equal; but I may say that "R.'s" method is used almost exclusively all over Scotland. I have seen four propellers made off the same mould by "R.'s" method, which it would be impossible to do with Mr. Ashcroft's method.

Yours, etc.,

"J. McC."

## REPLIES.

### Nickel and Copper.

"Nickel" must remember he is experimenting with a metal which has proved troublesome since its discovery. Perhaps the metal is too good, or, in other words, is too malleable and ductile to become fluid. When nickel is fused with carbon, the two elements combine to form a compound and give increased fluidity. If a little zinc is added in a good refractory crucible, and a fuel suitable for melting crucible steel is used, he should not have much trouble.

"W. R."

In regard to the trouble experienced by "Nickel," it must be borne in mind that nickel is a metal which fuses at about the same heat as wrought iron, the fusing temperature varying from 2,730 degrees F. to 2,920 degrees F., according to the content of the metal. For this reason very few ordinary brass furnaces will provide the necessary combustion of the hard coke sufficient to provide the heat, which is nearly the limit of that obtainable from the combustion of carbon under a naturally induced draught. In addition, really good crucibles are required to stand the high temperatures needed for the fusion of these high temperature metals, and where melting has to be done with fair frequency, it pays to instal special furnaces and crucibles, such as those made by the Morgan Crucible Company, of Battersea, which are made for high temperature work. Naturally, the best and hardest furnace coke would be used, and this should hold quite 90 per cent. carbon, and not more than 0.5 sulphur, if economy is desired. White heat, as commonly understood, is not sufficient to fuse nickel, as this heat is really only 1,300 degrees F., whereas, a temperature above the brilliant welding heat, which is dazzling white when nickel is melted alone, is required. It is advantageous to break the nickel up as small as possible, and as soon as it becomes white-hot, throw in some copper (when making Ni.-Cu. alloys, of course), as the copper fluxes the nickel and assists in bringing it down; but in regard to this particular point, some little practical experience is needed.

There is no necessity to use fluxes in the melting of nickel or other metals, provided you have good, hard coke, a proper furnace, and crucibles that will withstand the heat and wear. Usually, these things have to be specially provided, the ordinary furnaces and pots used for brass-melting not being good enough for the purpose.

"W. J. M."

## QUERIES.

### Gas Furnace for Copper.

Can you tell me of a small, compact-coal-gas furnace for melting, etc., copper bars and other alloys; capacity: to hold a 50-lb. pot?

"R. E. C. T."

MESSRS. T. DAVIES & SON, West Gorton Manchester, send us their catalogue of cupolas, blowers, ladles, and other foundry equipment.

## The "Foundry Trade Journal" Bookshelf.

### Electro-Metallurgy.

*By John B. C. Kershaw.*

To all who have watched the progress of mechanical science during recent years, the possibilities of electricity in the various branches of metallurgy will strongly appeal. The possibilities opened up by the application of electricity to refining processes and the general working of metals has given scope for the industrial application of many metals which were formerly classed as precious, or at least too costly for general industrial use. The subject treated by Mr. Kershaw in his book, which has just been placed before the public, is one which, while not exactly a foundry subject, will be of considerable interest to foundrymen, since it deals with the production of many metals which they are daily handling. Essentially the book deals with electricity as applied to the refining of ores, and the producing of metals, and while little mention is made of electricity as applied to foundry work the scope indicated for that power in the foundry will probably lead readers to take the subject up more fully.

The author's aim has been to give a brief and clear account of the industrial development of electro-metallurgy, in language simple enough to be thoroughly understood by those who have only a slight acquaintance with chemical and electrical science. Little attempt has been made to discuss the theoretical side of the subject, the book being rather an extensive summary of the history of metallurgical developments during the electric era. Following a short historical survey of the advancement recently made, the author treats with aluminium, its production under various processes, and gives a description also of various works producing the metal. Coming then to carbonundum, a mineral which has come very much to the front in recent years, its origin and uses are explained and details of the manufacture given. Copper is dealt with to some considerable extent, the refining processes and other different essentials being described, in addition to the refineries in the United Kingdom and other countries. The important part which various ferro-alloys play in the manufacture of iron and steel lends considerable interest to the chapter devoted to the subject. The properties of the alloys themselves are not dealt with to any great extent, the chapter being devoted more to a description of works and plants, including the furnaces used in the production of the metals. Nevertheless, there is a good deal in this chapter which will be useful to the foundryman. The application of electricity to iron and steel manufacturing processes is too big a subject to be dealt with to an adequate extent in the book, but nevertheless, the author has managed to condense into one chapter a good deal of important and useful information, including descriptions of different electrical furnaces and processes employed in the manufacture of steels. The distinctive features of each process are well noted, and also the comparative costs of operating the individual furnaces are given.

After dealing with the production of lead by electrolytic methods, miscellaneous products are treated, amongst which are calcium, magnesium, phosphorus, silicon and its compounds, including metallic silicon, siloxicon, and silicon copper. These various products are necessarily only dealt with briefly. Nickel, which, on account of the effect it has when combined with iron and steel, has come largely under consideration of late, is in this book treated fairly fully. The various processes of its manufacture are briefly but lucidly described. Following with some notes on sodium, the author deals with the alkaline process, acid process, and the salt process for tin stripping, concluding with the subject of zinc and its processes; different furnaces and apparatus are described, and following is a short treaties on electro-galvanising.

To the foundryman only eager for knowledge directly concerning his everyday work, there is perhaps not a great deal in this book to attract, but to a student of metallurgy, as a science, and to all who are interested in the development of our various industrial processes the book opens plenty of ground for thought, and would probably direct the attention of many of its readers to further works dealing more fully with the different topics.

*The publishers are Messrs. Archibald Constable & Company, Limited, 10, Orange Street, Leicester Square, W.C. Price 6s. net.*

## TRADE TALK.

THE DALZIEL BRIDGE AND ROOF BUILDING COMPANY, LIMITED, Motherwell, have found it necessary to suspend payment.

KELVIN & JAMES WHITE, LIMITED, of Glasgow, have removed their London office to 11, Billiter Street, E.C.

LETTERS PATENT have now been granted on the "Yorkshire" boiler in Germany, France, and Belgium.

MESSRS. W. G. ALLEN & COMPANY, Prince's End, Tipton, are at present making large extensions to their works.

THE HEXTHORPE BRASS WORKS, Doncaster, belonging to Messrs. Woodhouse & Company, have been very seriously damaged by fire.

MESSRS. G. ALEXANDER and R. K. RICHARDSON, Forth Engine Works, Kirkcaldy, trading as Alexander & Richardson, have dissolved partnership.

THE RIGHT HON. JOHN G. TALBOT, M.P., has resigned his directorship of Head, Wrightson & Company, Limited, of Stockton-on-Tees.

MR. W. J. PRIEST has resigned his position as managing-director of John Priest & Son, Limited, ironwork contractors and fencing manufacturers, of Bristol.

MESSRS. E. CRAVEN and G. CRAVEN, carrying on business as E. Craven & Company, steel founders, Leeds, have been adjudged bankrupts.

MESSRS. T. B. KENDELL, L. S. KENDELL, and S. E. HALL, engineers, Norfolk Place, Shoreditch, N.E., trading as T. Kendell & Sons, have dissolved partnership.

MESSRS. E. SPICER and C. M. BESTIC, engineers' store dealers, Salisbury House, E.C., trading as the Eclipse Engineering Company, have dissolved partnership.

FIRE broke out at Messrs. Joseph Berry & Sons' Engineering Works, at Swinton, Manchester, recently, but the damage was only slight.

THE Lancaster branch works of the Amalgamated Railway Carriage and Wagon Company, Limited, are being closed.

MESSRS. C. F. BROWN and H. I. LEWENZ, mechanical engineers, etc., Romsey, Hants, trading under the style of Hillier & Company, have dissolved partnership.

GOUGH, SPITTLE & BAUGH, LIMITED, Derby, have appointed C. Hornibrook & Company, Limited, 37, Crutched Friars, London, E.C., as their sole agents in London.

A FIRE broke out recently in the engine works occupied by A. & W. Smith, Limited, 126, Dale Street, Tradeston, Glasgow, doing damage to the extent of several hundred pounds.

A DISSOLUTION of partnership is notified in connection with Messrs. E. W. Walker and R. W. Murray, locomotive engineers, etc., Fishponds, Bristol, who traded as the Avonside Engine Company.

MESSRS. CHARLESWORTH, PEEBLES & COMPANY, of 53, Bothwell Street, Glasgow, have been appointed agents in Scotland for Fielding & Platt, Limited, of Gloucester.

MR. A. G. COLLINGS has resigned the agency of the Elmbank Foundry, and has been appointed the West and South-West of England and Welsh agent of the Carron Company.

VEITHARDT & COMPANY, LIMITED, engineers and agents, have removed from 10, Bush Lane, Cannon Street, London, E.C., to 26/27, Bush Lane, Cannon Street, London, E.C.

MR. L. H. FRY, European representative of the Baldwin Locomotive Works, Philadelphia, Pa., U.S.A., has left London and opened an office at 56, Boulevard Haussmann, Paris.

MR. F. F. HILL, 35, Bucklersbury, London, E.C., has been appointed London and Southern district agent for Messrs. T. A. Savery & Company, engineers, Newcomen Works, Birmingham.

THE COWAN BRANCH of Parkinson and W. & B. Cowan, Limited, have removed their London business from the Smith Square Works, Westminster, S.W., to Fitzalan Street, Kennington Road, S.E.

MR. D. MACFIE, at one time managing director of Jas. Milne & Son, Limited, engineers, Edinburgh, has established himself in business at 1, North Street, St. Andrew Street, Edinburgh, as a specialist in metal work, etc.

THE HYDRAULIC ENGINEERING COMPANY, LIMITED, of Chester, are supplying the North-Eastern Railway Company with the hydraulic machinery necessary for operating the new swing bridge at the entrance to the Albert Dock, Kingston-upon-Hull.

MR. H. NANCE, 4, Church Street, Cardiff, has been appointed as agent in South Wales and the West of England for Newtons, Limited (Taunton); Nalder Brothers & Thompson, Limited (London); and Wm. Wadsworth & Sons (Bolton).

## PERSONAL.

THE late Mr. G. Swift, machine tool maker, Halifax, left estate of the gross value of £10,248.

MR. G. SHAW SCOTT, M.Sc., of Sutton Coldfield, has been appointed secretary of the Institute of Metals.

THE late Mr. George G. Blackwell, whose death we announce in another column, left estate sworn at £27,198 gross.

MR. L. W. SMITH, works manager for Richard Garrett & Sons, Limited, Leiston, has been appointed to a similar position with W. Sisson & Company, Limited, engine builders, Gloucester.

MR. H. P. HARLAND, assistant manager of Harland & Wolff, Limited, Belfast, has been appointed assistant general manager and agent to the Chinese Engineering and Mining Company.

SIR ROBERT HADFIELD, on September 17, at the Sheffield Reform Club, was given a complimentary dinner by the members, in honour of the knighthood recently bestowed upon him.

THE gross value of the estate left by the late Mr. T. Beeley, head of Thomas Beeley & Son, Limited, Hyde Junction Boiler Works, Manchester, is £86,114, with net personalty £61,357.

MR. V. JOBSON has resumed his duties as manager of the works of the Derwent Foundry Company, Limited, Derby, after having been forced to take a rest of some months' duration in consequence of his health.

MR. BROOKES, a manager at the Saltley Works of the Metropolitan Amalgamated Railway Carriage and Wagon Company, Limited, has been transferred to the Company's Patent Shaft Works at Wednesbury.

MR. W. C. A. LANDON, a representative of Hadfield's Steel Foundry Company, Limited, is spending some months in Australia. The firm is represented in the Commonwealth by the McArthur Engineering Company, Limited, Sydney, and Mr. Landon intends visiting all the principal fields of Australia, in company with Mr. J. B. Wallis, the representative of the local agents.

MR. W. H. ALLEN, of W. H. Allen, Son & Company, Limited, Queen's Engineering Works, Bedford, and representative of the employers on the County Territorial Force Association, has enquired of the leading employers of labour in Bedfordshire if they would be prepared to give their men the necessary leave of absence for a fortnight, and how many of the workers were likely to join the force. The replies are stated to be of a favourable character.

## DEATHS.

MR. A. F. DUNCAN, a director of the firm of Robert Duncan & Company, Limited, shipbuilders, Port Glasgow, aged 47 years.

MR. SAMUEL MASTERMAN, at Manchester on September 25. He was for 14 years assistant secretary of the Friendly Society of Ironfounders, and was recently elected general secretary to the Society.

MR. J. W. SPENCER, chairman of John Spencer & Sons, Limited, of the Newburn Steel Works, Newcastle-on-Tyne, aged 65 years. He was also a director of John Abbott & Company.

MR. JOSEPH EVANS, the principal partner in the well-known firm of Joseph Evans & Sons, Limited, of the Culwell Foundry, Heath Town, Wolverhampton, aged 64.

MR. G. G. BLACKWELL, founder and principal of the well-known firm of Geo. G. Blackwell, Sons & Company, Limited, metallurgists, etc., of the Albany, Liverpool, and Cross Lane, London, aged 67 years.

MR. T. PERKINS, of Messrs. Barford & Perkins, engineers, of the Queen Street Iron Works, Peterborough, aged 86 years. The deceased gentleman will be remembered as the founder of the engineering works now carried on by Messrs. G. H. Innes & Sons, Station Iron Works, Hitchin.

MR. JOHN MOSELEY, J.P., at his residence, Cremlin, Highgate, Walsall, aged 51. The deceased gentleman was the senior partner in the firm of Henry Moseley & Sons, ironfounders and chain manufacturers, of Bath Street Works, Walsall. The firm is an old-established one, having been founded upwards of a hundred years ago.

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CAMMELL, LAIRD & COMPANY, LIMITED, Cyclops Steel and Iron Works, Sheffield, recently cast what is believed to be the largest nickel steel ingot ever cast, its weight being 114 tons. The ingot is a fluted octagon, 7 ft. across corners, 18 ft. 6 in. in length, necessitating a mould having the enormous weight of over 80 tons, and was cast in the heavy casting pit at the company's Grimesthorpe Works. This particular shop has recently been rebuilt, and is served by two 80-ton electric cranes, one 120-ton electric crane, and one 15-ton electric crane. The largest of the Siemens' melting furnaces, some of which are situated on either side of the casting pit, has a melting capacity of 65 tons. The ladle cranes are of special design, having regard to the economical and expeditious handling of molten steel.

## LIST OF NEW INVENTIONS.

Specially compiled for the FOUNDRY TRADE JOURNAL by MR. GEORGE BARKER, Fellow of the Chartered Institute of Patent Agents, 77, Colmore Row, BIRMINGHAM.

Applications, Aug. and Sept., 1908.

16,897. GIMSON & COMPANY (LEICESTER), LIMITED, and S. MCCONNELL. Improvements in or relating to the method of, and means employed for, moulding cylindrical bodies.

16,956. C. GRUNWALD, Improvements in the process of and apparatus for the manufacture of cast metal wheels.

17,732. A. CRUICKSHANK. Improvements in and relating to moulds for casting chains.

17,759. J. CHURCHWARD. Improvements in heat treating and quenching alloyed steels.

18,534. A. GUTENSOHN. Improvements connected with the process of briquetting metal oxide and metal sulphide material.

18,680. W. LESSING. Improvements in the process of briquetting ore with blast-furnace slag.

18,726. S. O. COWPER-COLES. Improvements for de-sulphurising and de-phosphorising iron.

18,768. S. A. COWPER-COLES. Improvements in the extraction of iron from its ores.

18,842. A. REYNOLDS. Improvements in the production of fused slags particularly applicable to the manufacture of steel and other metallurgical processes.

19,035. W. F. C. MCCARTHY. Process of treating iron and steel.

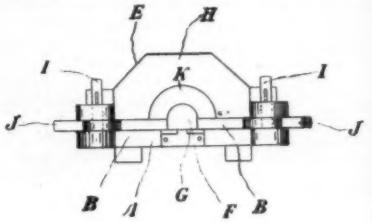
1907.

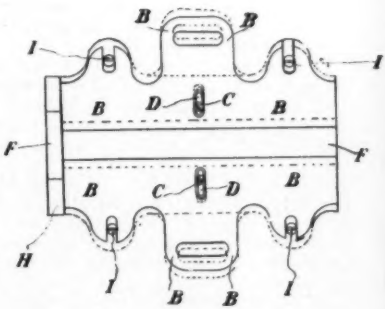
21,348. H. CUSTANCE and R. A. F. W. LAGERWALL, London. Improvements in or connected with moulds for casting metals.

This invention relates to improvements in or connected with metal moulds to be used in the casting of metal articles, the formation of which requires the use of a cone and such halves or sections of bearings, brasses or bushes, the object being to provide a mould which can be employed for casting an article with a bore of any required size or shape within certain limits.

For this purpose, the plate which constitutes that side of the mould which carries the core, has mounted at each side of its inner face a plate capable of being moved toward or from the centre of the side of the mould. Slots are formed in the said movable plates through which pass screws which enter corresponding holes in the said side of the mould, so that whilst the movable plates can be laterally shifted to accommodate between their inner edges a core of any required width, the heads of the screws will retain them up to the face of the side of the mould.

As shown in the illustration, the side A of the mould on which the core F rests, has mounted on its inner face the plates B, B, by means of screws C which pass through slots D, D, so that the plates, which grip the lower part of the core, may




be slid toward or from the centre of the side A according to the width of the core to be employed.

The side A at one end, has a gauge G fixed thereto to facilitate the arrangement of the core in the required central position and to the opposite end of the plate is fixed the plate H which closes that end of the mould.

The body E of the mould is secured to the side A by means of the cotter pins I which are fixed to the side and pass through slots in the plates B B and holes in flanges J at the sides of the body E.

In practise the cone F of suitable material is arranged centrally between the plates B, B, and is secured by screws D, D; the mould is then turned on one end, and the metal is run in through the opening made for that purpose.

# FOUNDRY LADLES.

28 LB.
—to—
30 TON.

**JAMES EVANS & CO.,** BRITANNIA WORKS,

TELEGRAMS—
"LADLES, MANCHESTER."
TELEPHONE—2307

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Llantrissant, October 25th, 1904.

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## PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

| Metals. | 1907-8. | 1906-7. |
|---|---|---|
| Iron—Scotch pig warrants ... ton | *56 0 | *63 6 |
| —Middlesbro' warrants ... ... ton | 57 3½ | 53 8 |
| —W.C. M/nos Bessemer ... ... ton | 61 6 | 76 0 |
| —Stock, Scotch, tons | 1,060 | 1,570 |
| Copper—Chili bars, GMB ... ... ton | £59 17/6 | £62 2/6 |
| —Stock, Europe & afloat... ... tons | 50,277 | 12,138 |
| Tin—English ingots ton | £134 10 0 | £161 0 0 |
| —Straits ... ton | £133 17/6 | £156 15/0 |
| —Stock, Ldn. Hind and afloat ... tons | 19,073 | 12,790 |
| Lead—English pig ton | £13/12 6 | £21 15 0 |
| Spelter—Ord. Silesian ... ... ton | £19/15 0 | £20 17/6 |
| Quicksilver—(75lb.) bottle | £8 5/0 | £7 7/6 |
| Antimony—Regulus ... ... ton | £31 10/0-£32 10/0 | £15 0/0-£46 0/0 |

*Settlement price.

### Castings.

In the Cleveland district the following are the nominal rates current for castings :—

| | £ s. d. | | £ s. d. |
|---|---|---|---|
| Columns (plain) ... ... ... | 6 15 0 | to | 7 0 0 |
| Pipes, 1½ to 2½ in. ... ... | 5 2 6 | to | 5 7 6 |
| ,, 3 to 4 in. ... ... ... | 4 15 0 | to | 5 5 0 |
| ,, 5 to 8 in. ... ... ... | 4 12 6 | to | 4 15 0 |
| ,, 10 to 16 in. ... ... | 4 12 6 | to | 4 15 0 |
| ,, 18 to 24 in.... ... ... | 4 12 6 | to | 4 15 0 |
| Chairs ... ... ... | 3 10 0 | to | 3 12 6 |
| Floor plates (open sand) ... ... ... ... | 3 2 6 | to | 3 5 0 |

### Scrap.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 5s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 6s. 0d.; all per ton f.o.b., London. Copper (clean), £54 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £12 5s. 0d.; tea lead, £10 10s. 0d.; zinc, £15 5s. 0d.; all per ton delivered merchant's yard.


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*Established 1863.*

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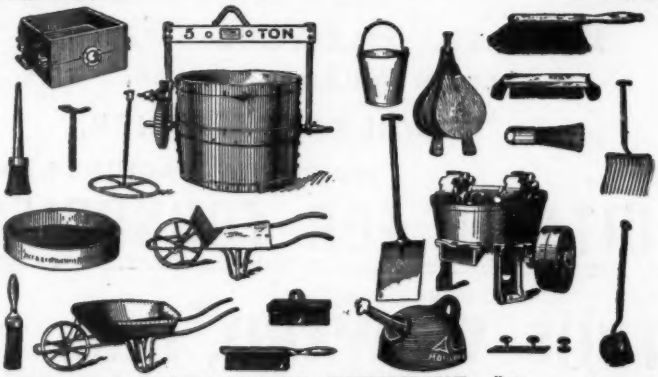


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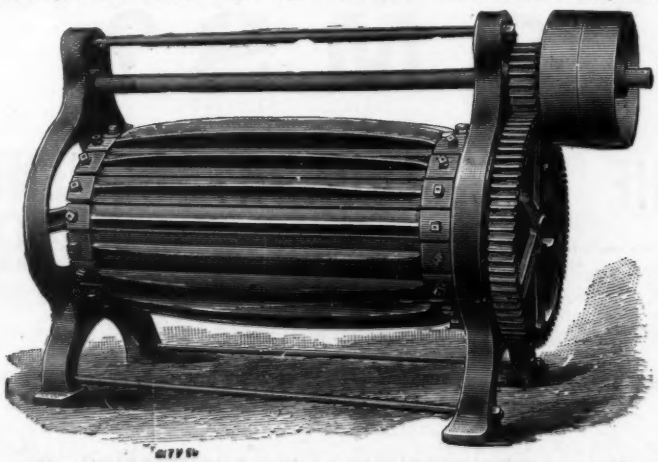

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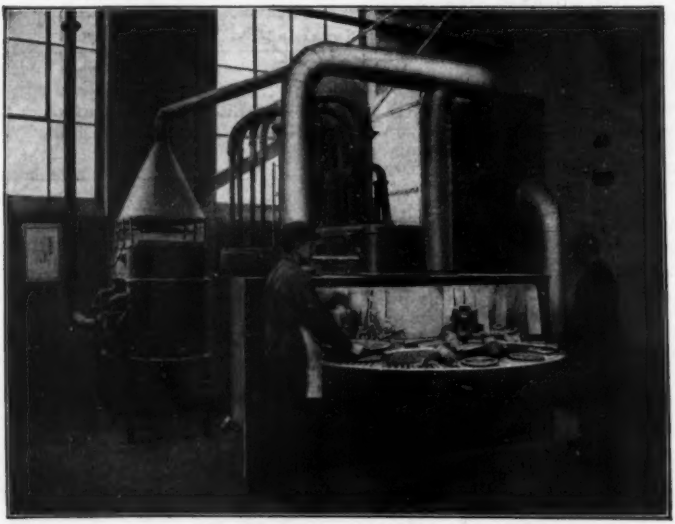

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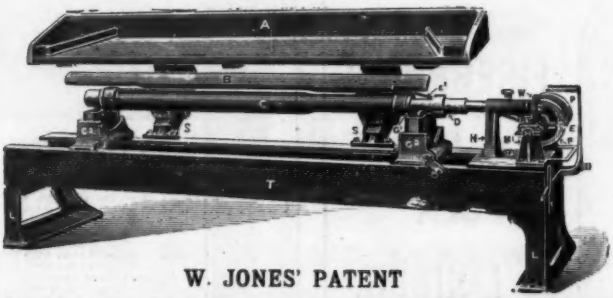

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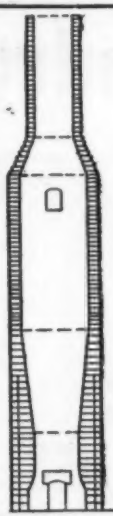

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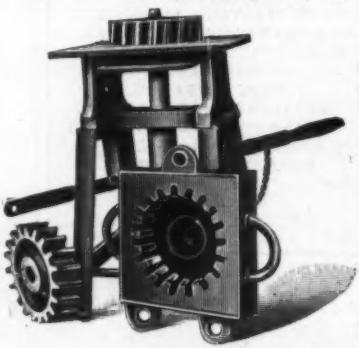

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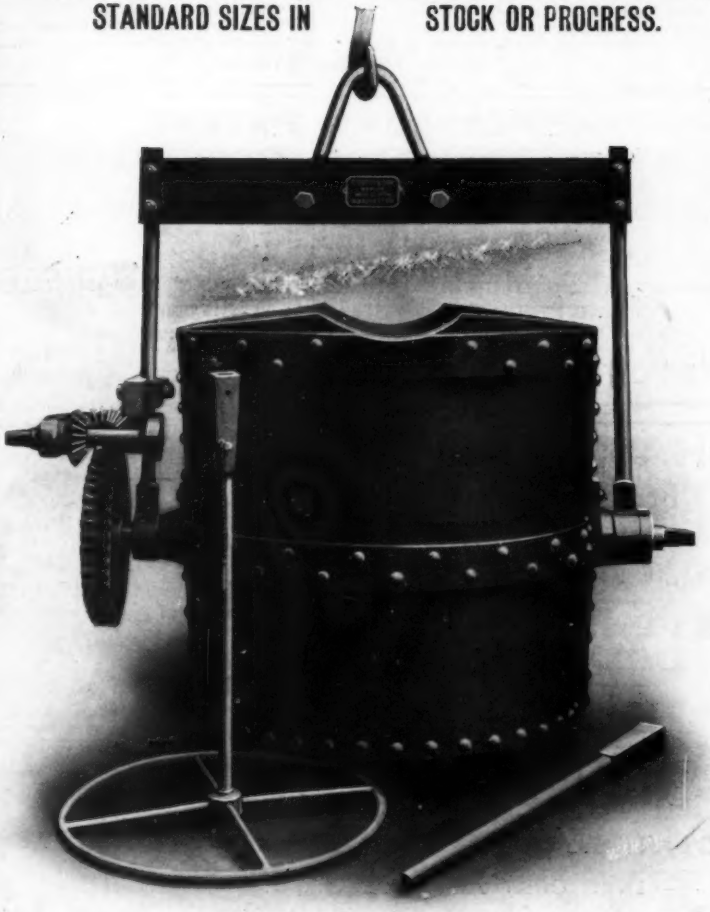

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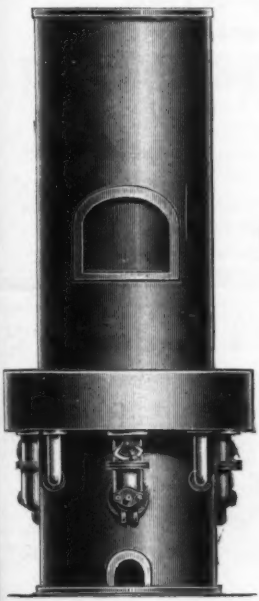

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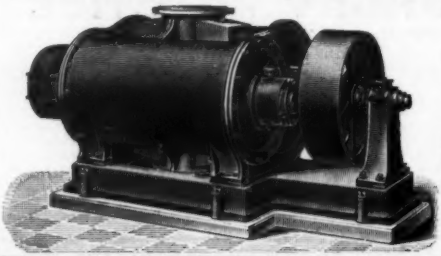

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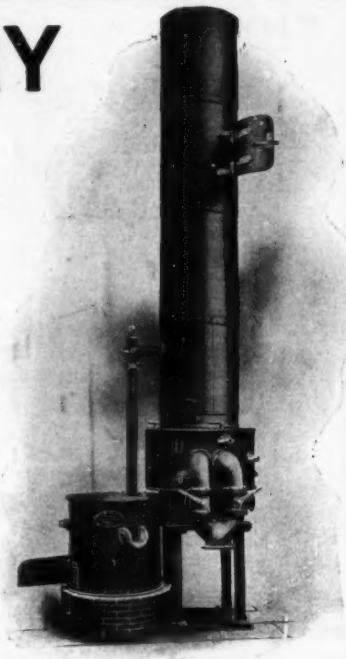

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